ATLAS
OF
PHYSICAL GEOGRAPHY:

PETERMANN
AND
MILNER.

ATLAS OF PHYSICAL GEOGRAPHY,

CONSTRUCTED BY

AUGUSTUS PETERMANN, F.R.G.S.

WITH DESCRIPTIVE LETTER-PRESS,

BY

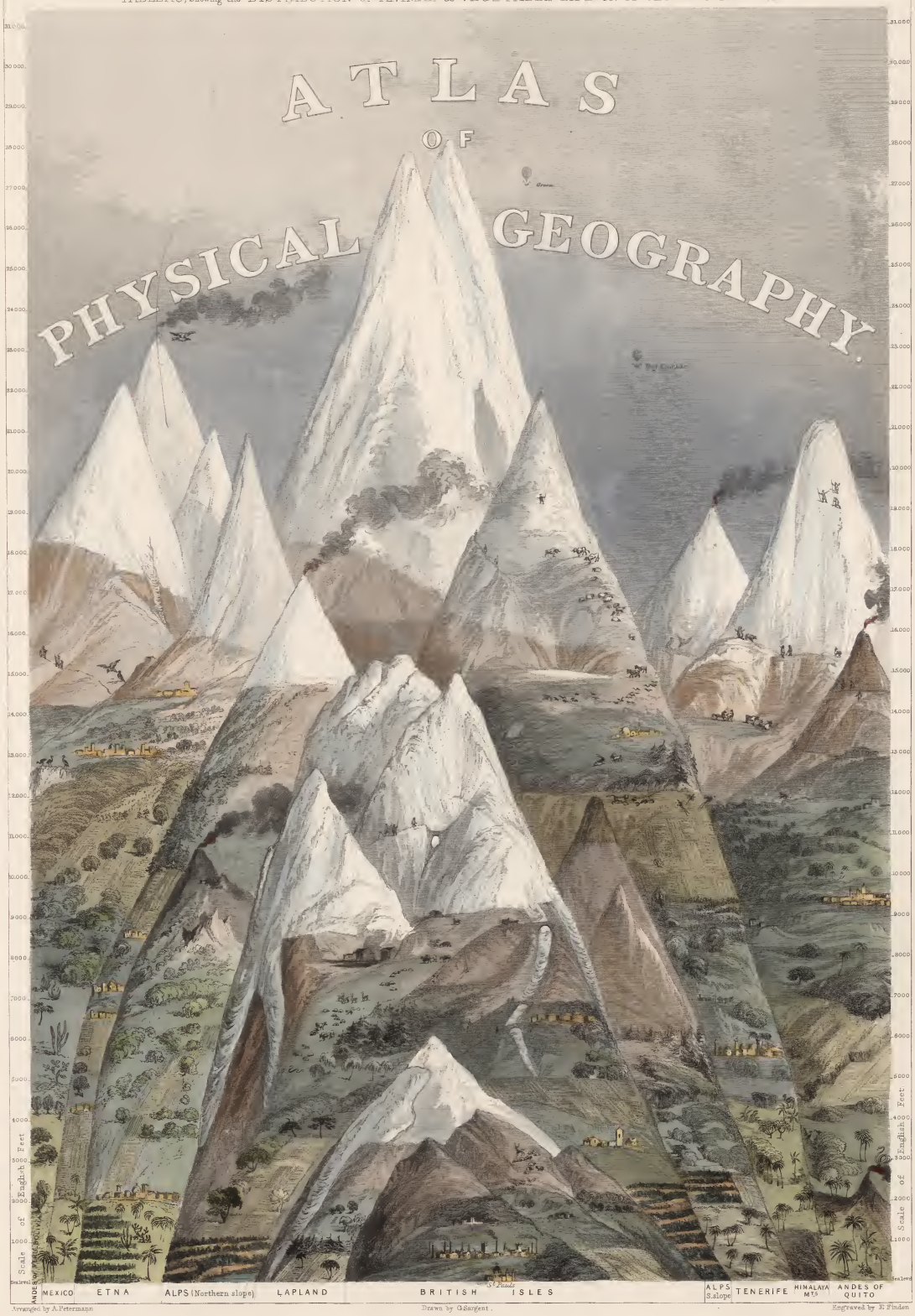
THE REV. THOMAS MILNER, M.A., F.R.G.S.

AUTHOR OF "THE GALLERY OF NATURE," ETC. ETC.

As man, after having passed through the different gradations of intellectual development, arrives at the full enjoyment of the regulating power of reflection, he no longer rests satisfied merely with a vague presentiment of the harmonious unity of natural forces; thought begins to fulfil its noble mission; and observation, aided by reason, endeavours to trace phenomena to the causes from which they spring. It is the perception of these relations that exalts our views and ennobles our enjoyments.

HUMBOLDT.

TABLEAU, Showing the DISTRIBUTION of ANIMAL & VEGETABLE LIFE IN ASCENDING REGIONS.



Arranged by A. Petermann

Drawn by G. Sargent.

Engraved by E. Finden

For Explanation see page 106.

LONDON. WILLIAM S. ORR & Cº

THE

ATLAS

OF

PHYSICAL GEOGRAPHY:

CONSTRUCTED BY

AUGUSTUS PETERMANN, F.R.G.S.

HONORARY MEMBER OF THE GEOGRAPHICAL SOCIETY AT BERLIN;

FORMERLY OF THE GEOGRAPHICAL ESTABLISHMENT AT POTSDAM, AND MANY YEARS ASSISTANT IN PREPARING THE GREAT PHYSICAL ATLAS OF BERGHAUS.

WITH DESCRIPTIVE LETTER-PRESS,

EMBRACING A GENERAL VIEW OF

THE PHYSICAL PHENOMENA OF THE GLOBE.

BY

THE REV. THOMAS MILNER, M.A., F.R.G.S.

AUTHOR OF THE "GALLERY OF NATURE," ETC. ETC.

Illustrated by One Hundred and Thirty Vignettes on Wood.

LONDON:

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MDCCCL.

TO

HIS ROYAL HIGHNESS

THE PRINCE ALBERT, K.G.

ETC. ETC. ETC.

THIS VOLUME,

ILLUSTRATIVE OF THE GREAT FACTS OF PHYSICAL GEOGRAPHY,

IS

WITH HIS GRACIOUS PERMISSION

Most Respectfully Dedicated

BY

HIS ROYAL HIGHNESS'S

VERY HUMBLE AND MOST OBEDIENT SERVANTS,

The Publishers.

PREFACE.

Physical Geography—that branch of the Philosophy of Nature which deals with the existing features of our terrestrial habitation, the arrangement of its inorganic materials into continent and island, mountain and valley, plain and river, with its atmospheric conditions, and the distribution of organic life upon its surface; subjects fraught with interest to the inquiring mind, as well as important to the pursuits of commerce and the social advance of mankind—has originated as a science during the present century, or at least it may be said to have acquired that amount of extension and accuracy since its dawn, which entitles it to rank with other departments of Natural Philosophy.

At the commencement of this century the great Physical Geographer of the age, Alexander Von Humboldt, was a transatlantic traveller, engaged in that remarkable journey with M. Bonpland, during which he investigated the phenomena of equinoctial America, disclosed its magnificent vegetation, rectified many errors in latitude and longitude, determined the bifurcation of its two grand rivers, ascended the elevated platforms of the Andes, and reached a height on the slopes of its volcanic cones, only surpassed by the flight of the condor. From this journey he returned to Europe, to inform and delight the intelligent with representations of natural scenery, blending the charms of imagination with the severity of science. Since that period, the same adventurous mind has visited Central Asia, and the *Fragmens Asiatiques*, the result of a journey in 1829, subsequently expanded into *Asie Centrale: Récherches sur les Chaines de Montagnes, et la Climatologie comparée*, have largely illustrated a region of the Globe before very obscurely known: while, animated by the zeal of the illustrious Prussian, many distinguished men of different nations have contributed to enlarge the boundaries of our knowledge concerning various localities, collecting data upon which a graphic representation of terrestrial objects may be grafted. The following facts will exhibit the remarkable progress recently made in one of the departments of this science:—In 1817, Humboldt based his Isothermal lines upon observations made in sixty places; in 1832, Kaemtz, of Dorpat, had increased the number to 145; in 1839, Berghaus, of Potsdam, published a list of 307; and in 1844, Humboldt, in his work on "Central Asia," gave as many as 422,—a statement strikingly illustrative of the advance of information relative to the distribution of temperature.

Berghaus was the first to propose and execute a representation of the physical features of the Globe in a graphic and pictorial form; and his great work, "The Physical Atlas," has proved of the greatest utility in the instruction of intellectual nations, besides embodying a vast variety of facts in a compact form, for the use of the scientific classes. Adopting the same plan, but employing original constructions, founded upon the most recent data, and embracing, with two exceptions, the entire surface of the Globe, so as to give a general outline of the system, the present Atlas of Physical Geography is designed to correspond to the existing state of knowledge. The exceptions to general Maps of the World will be found in the appended Physical Map of the British Isles, which is given on local grounds, and of Palestine and the adjacent countries, which, besides possessing some interesting physical phenomena, is given as constituting peculiarly the land of the Bible—the source of our religious faith, and the most ancient fountain of our historical knowledge.

The Editor cannot close this notice without the remark that, however he may have executed the part allotted to himself, he confidently anticipates for the graphical constructions of his colleague, that public sanction which their accuracy and beauty deserve.

Norwood, Surrey,
December 1, 1849.

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LIST OF THE MAPS.

NOTE.—Linear distances and superficial dimensions are given in British statute miles; elevations, &c. in English feet; and indications of temperature in degrees of Fahrenheit.

PHYSICAL GEOGRAPHY.

INTRODUCTION.

I. Physical or Natural Geography treats of the general features of the terrestrial superficies; the arrangement of the inorganic matter of the globe, and the distribution of organic life; the phenomena of the atmosphere, and its relation to the varied animal and vegetable productions with which the earth is replenished. The limits of this department of science are not strictly defined. The connection is so direct and intimate with the domains of Astronomy, Geology, Botany, and Zoology, that a trespass upon them is unavoidable in prosecuting this branch of physical inquiry.

II. The surface of our planet consists of unequal portions of land and water. The area of the dry to that of the fluid is as 1 to $2\frac{3}{4}$ according to Humboldt, as 100 to 270 according to Rigaud, or as 100 to 284 following other estimates. The fluid portion of the surface thus vastly predominates, occupying nearly three-fourths of the entire area of the globe. The ancients, whose geographical knowledge was very limited, considered the ocean to be much less extensive than the land. Their poetical expression of the "ocean stream" was probably founded upon this idea. In the middle ages, the sea was supposed to occupy about one-seventh of the terrestrial surface. Columbus seized upon this opinion with ardour, as favouring his hypothesis, that a westerly sail across the Atlantic would bring him to an undiscovered shore.

III. The solid and fluid portions of the surface are very unequally distributed; land predominating in the northern, and occurring in comparatively insignificant force in the southern hemisphere. The proportion of known land to the entire area of different latitudinal zones, is exhibited in the following table:

Land—Northern Hemisphere.		Land—Southern Hemisphere.	
Arctic Zone	0·400	Antarctic Zone	Unknown.
Temperate Zone	0·559	Temperate Zone	0·075
Torrid Zone	0·297	Torrid Zone	0·312
Total	0·441	Total	0·163

Its superficial extent in square miles is as follows:

Land—Northern Hemisphere.		Land—Southern Hemisphere.	
Arctic Zone	3,252,589	Antarctic Zone	Unknown.
Temperate Zone	28,531,631	Temperate Zone	3,828,036
Torrid Zone	11,628,440	Torrid Zone	12,215,735
Total	43,412,660	Total	16,043,771

If we suppose the quantity of land in the northern hemisphere to be represented by 16, the amount in the southern will be scarcely equal to 5.

IV. Considering the globe to be divided, not in the line of the equator, but in that of the meridian of Teneriffe, the quantity of land and water in the two divisions is still very unequal, land predominating in the eastern half, while the western is specially oceanic. But if we take London to be the centre of a hemisphere, and its antipodes near a small island to the south-east of New Zealand, called Antipodes Island, to be the centre of the other, the inequality in the distribution of the components of the surface will strikingly appear. The first hemisphere will include nearly all the superficial land, and the other, excepting New Holland, a part of South America, and some islands will be oceanic.

V. There are no considerable antipodal surfaces of land, except where Chili and Patagonia oppose the eastern part of China; and the volcanic islands of Sumatra, &c., oppose the volcanic mountains of Quito. The great tract of New Holland is opposite to the deep centre of the Atlantic. Only about $\frac{1}{77}$th part of the present continents and islands has land opposed to it. The line of 16° west longitude, and 164° east longitude, is the meridian of least land. It passes by Kamschatka, the west side of New Caledonia, near the west side of New Zealand, and the west coast of Africa, near Madeira, Teneriffe, and the Cape de Verde islands. On this line it is almost all sea.

VI. The preponderance of land in the northern hemisphere indicates the superior intensity of the causes of elevation in northern latitudes at a remote geological epoch.

VII. Large continuous masses of land are termed continents, a Latin derivative signifying *connexion*. There are two grand examples: the Eastern Continent, which includes Asia, Africa, and Europe, otherwise styled the Old World, from its being the only one known to Europeans previously to the close of the fifteenth century; and the Western Continent, or the New World, which includes North and South America. The terms eastern and western refer to the meridian of the Ferro isles, from which longitude was formerly reckoned.

The rank of a continent has been assigned by some geographers to New Holland; but it is so far inferior in extent to either of the other masses, as to be more correctly placed in the class of islands. New Holland, however, with the innumerable islands of the Pacific and Indian oceans, ranks after Europe, Asia, Africa, and America, as a fifth great division of the globe, under the title of Oceania.

On many maps of the world, constructed in the interval between the discovery of the southern seas, and their navigation by Captain Cook, an immense continent figures, stretching out from the south pole, and filling the Antarctic regions, under the name of *Terra Australis Incognita*. Though no evidence of its existence could be adduced, yet speculative geographers firmly clung to the conviction of its reality, on the ground that an imaginary law of equipoise required such a continent in the southern hemisphere, to balance the great mass of land in the northern. The last formal advocate of a great habitable world in that region, Alexander Dalrymple, in 1772, sought to induce the Government to patronise an expedition, to be conducted by himself, stipulating that he should be allowed to retain for five years all the countries discovered in the southern ocean, between the longitudes 0° and 60° west of Greenwich. The researches of Captain Cook, who reached the high latitude of 71° 15′ S., encountering only some small islands, banished the dream of a *Terra Australis*, abounding in accessible mineral wealth, capable of sustaining vegetable life, and providing a new home for the human race. Yet it still remained an open question, whether there were not immense tracts of land lying between his limits and the south pole, or nothing but a frozen ocean. This question has recently been determined in favour of the former supposition, by separate expeditions under the auspices of the French, American, and British Governments. But it has not been positively ascertained that the respective coasts discovered are continuous, so as to form what may be called an Antarctic Continent.

In the opposite hemisphere, Greenland may be the projection of an arctic continent, extending round the north polar point.

VIII. Smaller portions of land, surrounded by water, are termed Islands. They are true continents in miniature, as the great masses are everywhere engirdled by the ocean. A considerable number of islands closely clustered, is called an Archipelago. Semi-islands are portions of land cut off from an adjoining shore at high water, appearing in connection with it upon the retreat of the tide. A home example occurs off the coast of Northumberland, in Holy Island, the Lindisfarne of the Saxons, which is accessible at low water to vehicles of all kinds from the main shore across the Fenham Flats.

IX. A part of a continent running out into the sea, so as to be nearly insulated, being connected with the main land by a small portion of its own circumference, or a narrow neck, is named a Peninsula, signifying almost an island, as Italy, Spain, and the Morea. The peninsular form is a very common feature of the land; and almost all peninsulas follow a southerly direction. This rule applies to Scandinavia, Spain, Italy, Greece, Africa, Arabia, India, Malacca, Cambodia, Corea, and Kamschatka, in the eastern hemisphere; and in the western, to South America, California, Florida, Alaska, and Greenland. The

peninsulas of Yucatan and Jutland are the chief exceptions. The cause of this singular fact remains in obscurity. A narrow neck of land connecting two large masses, is denominated an Isthmus, as the Isthmus of Suez, which unites Asia and Africa; and the Isthmus of Panama, joining North and South America.

X. Inferior projections of land into the sea, are variously named Capes, Promontories, Points, and Headlands.

XI. The continuous fluid which environs the land constitutes, properly speaking, a vast single Ocean; but it is conveniently distributed into partial oceans, which are named after their localities. A smaller extent of water, especially if it penetrate far into the interior of a continent, is termed a Sea, of which the Mediterranean, the Baltic, and Black Seas are examples. The more partial intrusion of an ocean or sea into the land is characterized as a Bay, or Gulf, as the Bay of Biscay, and the Gulf of Bothnia. A narrow passage connecting two seas together, or a bay with the main ocean, is styled a Strait; as the Straits of Gibraltar, by which the Mediterranean and the Atlantic are united.

XII. A large inland body of water, not connected with the ocean, or only communicating with it by means of a river, is termed a Lake. The Caspian Sea, a true lake, the largest in the world, owing to its size and saltness, has been dignified with the name of Sea.

GEOLOGY.

CHAPTER I.

GENERAL STRUCTURE OF THE LAND.

I. The horizontal profile of the land, as seen in journeying through a comparatively level country, and the vertical profile, as exposed by the side of mountains, ravines, and sea-cliffs, exhibit a great variety of substances, formations, or rocks, differently arranged.

Popularly the term rock is applied only to the more compact and solid portions of the globe, but geologically it extends to every kind of formation; to the loose sands, clays, and gravels, as well as to the limestones and granites. Eighty beds of different kinds have been found in a depth of 500 yards.

II. The perforations of the miner extend but a little way below the surface where they are carried on in vertical depth, and scarcely more than 2000 feet below the level of the sea, which is only about $\frac{1}{3\,8\,0\,0}$th of the semi-diameter of the earth. But in consequence of formations having been tilted up by the action of subterraneous disturbing forces, so as to be brought to or near the surface, the geologist has obtained a knowledge of the structure of the globe to the depth of about ten miles.

The Tresavean, the deepest mine in Cornwall, reaches to upwards of 300 fathoms (1800 feet). Shafts have been sunk to nearly the same depth in the Newcastle coal-field. The works of the coal-pit at Apendale, in Staffordshire, are carried on 2175 feet beneath the surface. Those in the Samson pit at Andreasberg, in the Harz, reach 2062 feet. At St. Daniel and at Geist, on the Röhrerbühel, the workings were 2916 feet in the sixteenth century; and the Eselschacht at Kuttenberg, in Bohemia, before it was abandoned, had attained the enormous depth of 3545 feet.

These are some of the greatest *absolute* depths, or below the immediate surface, to which man has penetrated. The greatest *relative* depth, or below the sea-level, is far less; perhaps attained at New Salzwerk, Minden, in Prussia, where the bore, in June, 1844, had reached 1844½ Parisian feet, or about 1970 British feet.

Mines in the Saxon Erzgebirge are respectively 1824 and 1714 feet in absolute depth, but only 626 and 260 feet in relative depth. The level of the sea has not been attained by the workings in Joachimsthal, Bohemia, where the depth beneath the surface is 1919 feet. The Planes de San Bernard, a mine in Mexico, 1582 feet deep, does not reach the level of the sea by 5592 feet (Humboldt).

III. It belongs to the chemistry and mineralogy of geology to examine the composition and internal structure of rocks, while Physical Geography deals with their external aspect; yet a brief reference to the former topics will not be out of place. Of fifty-four elementary or simple substances, that is, those which are incapable of further analysis, sixteen form by their various combinations nearly the whole of the matter yet known to enter into the composition of the globe.

These are as follows, arranged in three classes, according to their amount; the first in each class being the most abundant:

1. Six metalloids, or the bases of the earths and alkalies—silicum, aluminum, potassium, sodium, magnesium, calcium.
2. Two metals proper—iron, manganese.
3. Eight non-metallic substances—oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, fluorine, phosphorus.

The metallic substances mentioned, united with oxygen, form the great mass of rocks, consolidated and unconsolidated.

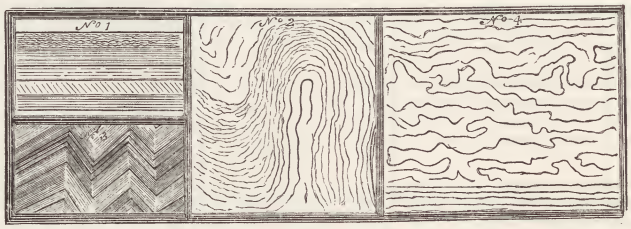
IV. The elementary substances are rarely found by themselves in nature, but combined with each other as binary or ternary compounds, forming the simple minerals, of which eight or nine constitute the great mass of all known rocks.

The important minerals are quartz, felspar, mica, hornblende, carbonate of lime, tale, chlorite, augite, serpentine; oxide of iron is also very common.

V. Sometimes the simple minerals exist in large independent masses, as quartz and carbonate of lime; but in general two, three, or four minerals are united to form a rock. Frequently the mineral constituents of a mass have been so much ground down, previous to consolidation, as to make the rock appear homogeneous, as shale and clay-slate.

The manner in which the ingredients of rocks are arranged exhibits several varieties:—The Granular texture, as in granite, distinct grains or crystals being confusedly compacted together; the Fibrous texture, as asbestos, a compost of long and minute fibres; the Porous texture, as pumice-stone, penetrated by pores; the Laminar texture, as mica-slate, an arrangement in thin plates or divisions. The laminar structure presents many diversities; horizontal and inclined; contorted; zigzag; and disturbed between horizontal laminæ. The varieties of lamination, which is almost entirely confined to sedimentary rocks, result from the different circumstances under which deposition has taken place, in quiet or troubled waters, upon a horizontal or a steep shore, and subject to lateral or vertical pressure.

1. Different kinds of lamination, wavy, horizontal, and inclined.
2. Contorted lamination, from a loose block of gneiss, in Colebrook, Connecticut, United States.



3. Angular lamination from a coal stratum.
4. Disturbed lamination between horizontal laminæ, from an argillaceous bed at Deerfield, Massachusetts.

Varieties of Lamination.

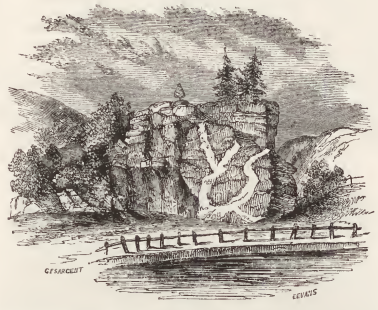
GEOLOGY:—PLUTONIC, VOLCANIC, METAMORPHIC, AND AQUEOUS FORMATIONS.

VI. The formations which constitute the solid matter of the globe accessible to man, are divisible into the four grand classes of Plutonic, Volcanic, Metamorphic, and Aqueous rocks, referring to the modes in which they have been produced.

VII. The Plutonic rocks, as the designation implies, are of igneous origin. They consist of crystalline masses, which, while in a melted state, were gradually cooled and consolidated at an immense depth under enormous pressure, and then upheaved by the elastic force of internal heat. But frequently the upheaving must have taken place before complete consolidation, as we find them protruded into cracks and fissures of superincumbent formations. Granite and its varieties, with some porphyries, belong to this class. They have no organic remains.

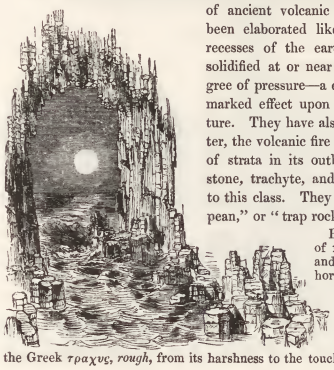
The appearance of granite, in Glen Tilt in Scotland, intruded into beds of clay, slate, and limestone, as observed by Dr. Hutton, first settled the question to his mind of that rock being the result of igneous fusion. The junction is shown in the cut.

An example of granite traversing the cracks of previously-formed granite, from the vicinity of Carlsbad, in Germany, clearly shows that it must have been injected in a fluid state, and proclaims two eras of formation in the mass.



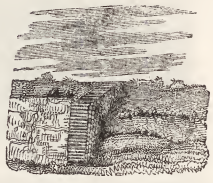
The varieties of granite arise from one of its constituents, quartz, felspar, and mica, being unusually predominant, or entirely wanting, or another mineral supplying its place, or being added to the other three. Hence there are granites of two, three, and four ingredients. Where mica is replaced by hornblende, we have Syenite; and where the substituted mineral is chlorite, we have Protogine. Syenite has its name from Syene, in Egypt, where the beautiful red granite of the Egyptian statues occurs in abundance. Protogine, a term of the French geologists, forms the highest peaks of Mont Blanc. Granitoid rocks lie at the base of all other formations, shrouded from the observation of man by layers of enormous thickness; but they appear also largely at the surface in various parts of the world, having been uplifted at different eras, and constitute the nuclei and crests of some principal mountain chains.

VIII. The Volcanic rocks, due likewise to the action of fire, are the produce of ancient volcanic eruptions. They have not been elaborated like the plutonic in the deep recesses of the earth, but for the most part solidified at or near the surface, with a less degree of pressure—a circumstance that has had a marked effect upon their appearance and structure. They have also a more diversified character, the volcanic fire having fused different kinds of strata in its outbursts. The basalts, greenstone, trachyte, and various porphyries, belong to this class. They are frequently called "trappean," or "trap rocks." No organic remains.



Basalt is composed ordinarily of felspar and augite, or felspar and hornblende, with iron. When hornblende predominates, the rock is called greenstone, from the peculiar colour of that mineral. Trachyte is essentially composed of glassy felspar, and derives its name from the Greek τραχυς, *rough*, from its harshness to the touch. The term porphyry is not applied to any particular kind of rock, but is used with reference to structure merely, denoting rocks with a homogeneous, compact, or earthy base, through which are disseminated crystalline masses of some other mineral of contemporaneous origin with the base. Thus we have basaltic, greenstone, and trachytic porphyries, the base being basalt, greenstone, and trachyte. Porphyritic rocks are termed amygdaloidal, when the embedded mineral substances have an oval or almond-shape, from the Latin *amygdala*, an almond.

The term "trap," derived from the Swedish *trappa*, a stair, has been applied to such rocks, because of their frequent arrangement in the form of steps. They occur in large irregular masses, upon which some of our feudal castles have been founded; as Bamborough Castle, in the north of England, which rests upon basalt. But the columnar structure, as at Fingal's Cave, peculiarly characterises the trap rocks, and is frequently exhibited by basalt and greenstone. The columns are regular prisms, with sides varying in number from three to eight; but they are commonly pentagonal, and form vertical, inclined, and horizontal ranges. It has been ascertained by experiment, that the columnar arrangement arises from the pressure of numerous spheroids on each other in the act of cooling.



That the trap rocks are the result of igneous activity, is clearly proved by the alteration of sedimentary formations in contact with them, slate having been changed into shale, sandstone into quartz, limestone into crystalline marble, and coal into coke, the effect of heat. Their junction also with other formations, filling up fissures and interstices, and spreading out in overlying masses, like a modern lava current, evidences the same fact.

IX. The Metamorphic rocks are of sedimentary origin; but having been in contact with the plutonic while in a state of igneous fusion, they have been altered in their texture, and crystallised, by the action of intense heat. The gneiss, mica-schist, and part of the clay-slate systems, belong to this division. They are non-fossiliferous.

Gneiss, a term of Saxon origin, has the same constituents as granite, but not commonly in the same proportion. They are also less entire, and have less asperity, as though the sharp angles had been rounded by being water-worn. The rock has a very wide geographical range. In England and Wales it scarcely appears at all, but forms a considerable portion of the main land and western islands of Scotland.

Mica-schist has two of the ingredients of granite and gneiss, but differs from them in the absence of felspar. Though there are no important examples in South Britain, it occurs in force in Ireland and Scotland, and is widely distributed.

Clay-slate is eminently argillaceous, as the name implies, consisting of clays variously indurated. It is extensively developed in Cumberland and North Wales, and forms on that account the Cumbrian and Cambrian group of some geologists.

X. The Aqueous rocks are those which are entirely due to the action of water, having either been deposited as mere sediment by its mechanical agency in connection with gravity, or as chemical precipitates from solution. Formations of this class constitute by far the greater portion of the exposed crust of the globe. They are all fossiliferous, and form three divisions called Primary, Secondary, and Tertiary, subdivided into systems and groups. The primary and part of the secondary series are sometimes termed Paleozoic, indicating the fact that the formations so named contain the fossil remains of the earliest formed animals.

I. PRIMARY.

1. Sub-silurian group, a part of the clay-slate system, marked by the dawn of organic life, the morning twilight of the era of living beings. *Organic remains.*—Lamelliferous zoophyta, and Brachiopodous mollusca, with traces of Annelidans, worms formed of annular segments, the first class in Cuvier's arrangement of articulated animals.

Nereites Cambrensis.

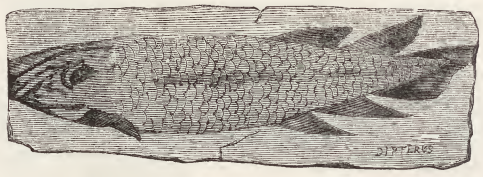
2. Silurian system, deposits lying upon the slates of Wales, and occupying some of the border counties, named after the locality, the country of the ancient Silures. The series has been recognised in different parts of Europe, in Africa, and America. *Organic remains.*—Zoophytes in great abundance and of many species, among which, the chain coral, catenipora escharoides, is a beautiful and characteristic specimen; Crinoideans, or Encrinites, lily-shaped animals, of several varieties; Crustaceans, particularly the trilobites (three-lobed) of several genera, and many species; Molluscs in great numbers; Traces of true vertebrated fishes, and of plants allied to the algæ, (sea weeds,) the equiestaceæ, (the horse-tails of our swamps and ditches,) and filices, (ferns.)

Catenipora escharoides.

GEOLOGY:—OLD AND NEW RED SANDSTONE, CARBONIFEROUS OOLITE, AND CRETACEOUS SYSTEM.

II. SECONDARY.

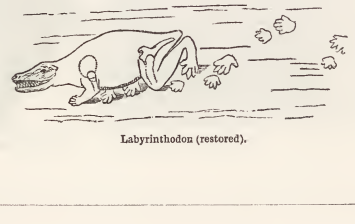
3. Old Red Sandstone, or Devonian system, largely developed in the west of England, and upon an immense scale in Scotland, occupying also vast areas of southern Russia, Siberia, and Tartary, and occurring on the southern flanks of the Himalaya mountains, and in various parts of the western world. The system is named in reference to its eminently arenaceous character, and predominant colour, a dark brick-red varying to a cream yellow, arising from iron oxide. *Organic remains.*—Plants, a few unimportant examples. Ichthyolites, or fossil fishes, belonging to the vertebrated order, are the characteristic fossils. The tails are heterocercal, or unequally lobed, as in the shark. Several genera, as the Dipterus, (double-winged,) have the vertical fins on the back and under the tail double.



4. Carboniferous system, embracing the mountain limestone and the coal measures, abundant in Great Britain and the United States; one main cause of their commercial greatness, but proportionably more extensive in the British islands than in other parts of the globe. The system is locally developed in France, Belgium, Saxony, Bohemia, Westphalia, on the north of the Carpathians, in Russia, Syria, the basin of the Indus, in China, and New Holland. *Organic remains.*—Zoophytes, molluscs, and fishes in abundance, with some crustaceans, in several instances of fresh-water origin. The mountain limestone is sometimes called the encrinal limestone, from whole masses of rock being almost wholly composed of the articulated stems of encrinites. Plants of many races, and generally of terrestrial growth, coniferæ, stems of sigillariæ, stigmariæ, and calamites of great size, with the foliage of arborescent ferns, like those within the tropics, in profusion, are the characteristic fossils.

Tropical Fern.

5. New Red Sandstone system, consisting of variously-coloured marls, sandstones, and magnesian limestones, with masses of rock salt, hence sometimes called Poikilitic, (variegated,) and Saliferous, (salt-yielding;) appears largely in midland England, in central Europe, and composes many of the river-valleys of the United States. The upper portion of the series, as exhibited in France and Germany, is there recognised as a separate system under the name of Triassic, as consisting of three principal groups; the lower portion, comprising the magnesian limestone, has been recently styled the Permian system, in allusion to the locality where it is exhibited upon a grand scale, the ancient kingdom of Permia. This district extends about 700 miles from north to south, and nearly 400 from east to west, between the Ural mountains and the river Volga. *Organic remains.*—Plants, terrestrial and marine, with fishes, common to the carboniferous period, but in several instances peculiar; reptiles, the earliest instance of their occurrence, saurians and lizards, among which are frogs of enormous dimensions, as the labyrinthodon, a generic name referring to the labyrinthine, or intricate inflections of the teeth; Ichnolites, (foot-prints on stone,) of

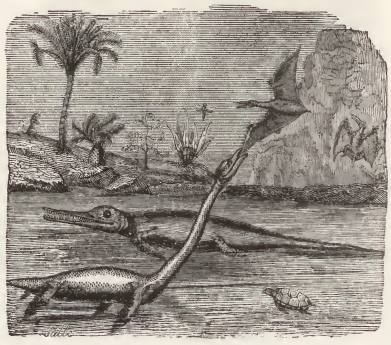


Labyrinthodon (restored).

Tracks of the Chirotherium.

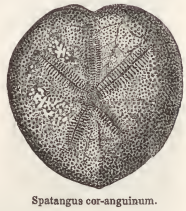
which some are called *sauroidichnites*, the supposed traces of reptiles, as those of the Chirotherium, so named from the impressions resembling the human hand in shape; others *ornithichnites*, the supposed tracks of birds; and others, *tetrapodichnites*, the supposed footsteps of an unknown four-footed animal.

6. Oolitic system, comprising the lias group and the Wealden formation, a collection of clays and limestones of various shades, the latter containing small calcareous globules, resembling the roe or eggs of a fish, and hence the name of the system, oolite, (egg-stone,) from the Greek. It occupies an extensive area of England; appears in various parts of Europe, but no true representatives are said to have been observed in America. *Organic remains.*—The most remarkable are those of marine saurians, the Ichthyosaurus, (fish-lizard,) the Plesiosaurus, (akin to the lizard,) with crocodilians of extant species; the Pterodactile, (wing-fingered reptile,) a flying saurian; the Megalosaurus, (great saurian,) a gigantic carnivorous terrestrial lizard; the Iguanadon, a huge herbivorous reptile, allied to the living Iguana; and Marsupial relics, allied to the opossum, the earliest type of mammalian organisation.



Restorations of Saurians, &c

7. Cretaceous system, a scheme of deposits which comprises green sands, chalk marl, provincially called gault, and chalk, with chert nodules and layers of flints, entitled after the Latin name of the prominent mineral, *Creta* (chalk.) It is conspicuous in the eastern and southern counties of England, spreads over wide areas of France and Germany, and occurs abundantly in North America. *Organic remains.*—Few examples of land organisms; plants, rare and nearly all referable to marine types; sponges, zoophytes, star-fishes, shells, and echinites abundant, as the *spatangus cor-anguinum*, heart-shaped echinite; vertebrated fishes; and the mososaurus, (lizard of the Meuse,) named from the place where it was first discovered, an aquatic reptile.



Spatangus cor-anguinum.

III. TERTIARY.

8. The Tertiary system, consisting of loosely aggregated beds of marine and fresh-water origin, occupies more than half the surface of Europe, and forms the site of three of its capitals—London, Paris, and Vienna. There are three principal groups:

1. The Eocene, (dawn of recent,) or lower tertiaries. 2. The Miocene, (less recent,) or middle tertiaries. 3. The Pliocene, (more recent,) or newer tertiaries. The nomenclature refers to the approach which the imbedded fossils make to existing nature. A fourth group is sometimes added, the Pleistocene, (most recent,) embracing the superficial accumulations of gravel, sand, and erratic blocks. *Organic remains.*—Plants, few marine, but the fresh-water beds have yielded cycadeæ, coniferæ, palms, poplars, willows, elms, chestnuts, sycamores, &c.: Fishes, mostly of extinct species; Molluscs, in great abundance, many belonging to living species; Reptiles, genuine crocodiles, serpents, tortoises, turtles, and prototypes of the frog tribe; Birds, referable

Animals of Paris Basin.

a Palæotherium magnum. *b* Palæotherium minus.
c Anoplotherium commune. *d* Crocodile.

to the genera, buzzard, owl, quail, woodcock, sea-lark, curlew, pelican, albatross; Mammalia, belonging to various orders.—*Pachydermata*, (thick-skinned,) palæotherium, anoplotherium, mastodon, elephant, hippopotamus, rhinoceros, horse, boar, tapir, &c.—*Quadrumana*, (four-handed,) monkey tribe.—*Carnivora*, (flesh devourers,) bear, hyena, fox, dog, seal, cat, weasel, &c.—*Rodentia*, (gnawers,) beaver, rat, hare, squirrel, &c. *Ruminantia*, (cud-chewers,) stag, deer, elk, antelope.—*Cetacea*, (whales.)—*Edentata*, (toothless animals, or with only molar teeth,) megatherium, glyptodon, mytodon, related to the existing diminutive sloths.

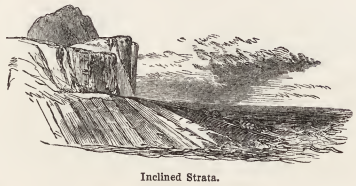
XI. The order of succession in the metamorphic and aqueous rocks, which has been stated ascendingly, is invariably maintained, that is, while many members of a group, and entire systems may be wanting, wherever they do occur, they are found to occupy the same relative position. Thus, if the old red sandstone is at the surface, the carboniferous system is not the under-lying formation. Chalk beds are never found below the coal measures, or the coal measures below rocks of clay-slate; but either chalk or coal may occur immediately above the slate, the intermediate formations being absent.

XII. The igneous rocks, plutonic and volcanic, exhibit generally amorphous, or irregular masses, without divisional structure, but broken by fissures, the summits being dome-shaped, globular, or deeply serrated ridges, in the form of needles, as the Aiguille de Dru in the valley of Chamouni. The metamorphic and aqueous rocks, on the contrary, are disposed in the form of beds, layers, or

Peter Botte Mountain, Mauritius.

strata, both horizontal and inclined at all angles to the horizon. The plains and low portions of the earth are occupied almost universally by stratified rocks. They appear also in elevated districts, and on the flanks of mountainous regions. Strata vary in thickness from a few inches to many yards and fathoms.

Had the rocks of deposition been formed in quiet waters, and kept free from disturbing forces, the position of strata would have been uniformly horizontal. But this has not been the case, and consequently strata are generally found to dip to some point of the horizon, as represented in the cut. It is clear that this inclination of the strata is due to an elevating cause which acted subsequent to deposition.



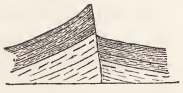
Inclined Strata.

Sometimes the strata have been lifted into a vertical position, or variously curved

and contorted by the disturbing force. An example of vertical strata is given, or nearly so, from the rock on which Powis Castle is built; of curved strata, from one of the western islands of Scotland; and of contorted strata from the banks of the Wye. (Figs. 18, 19, 21.)

Frequently horizontal beds appear divided by the inclined, which latter were plainly elevated before the deposition of the former; or horizontal beds rest upon a highly inclined stratified base, while a series inclines in a different direction. In such cases, of which illustrations are given, the stratification is said to be unconformable, or discordant.

Strata very commonly present examples of interrupted continuity, cracks and fissures occurring, varying in breadth from a few inches to many feet and yards. These are termed faults, the divided parts often exhibiting a change of level. But instead of being simple fractures, faults are sometimes open fissures, and chasms filled with angular dispersed fragments from the rocks above, or with igneous products injected from below.



XIII. The general conclusion obviously indicated by the preceding facts is, that the rocks of fusion, or the unstratified masses, which constitute the basis of the crust of the earth, have been repeatedly erupted through and into the stratified formations, at different epochs of critical action among the subterranean agencies of heat. Hence the various dislocations of the stratified rocks, their disturbed and inclined positions, their upheaval above the deep in which they were deposited, and frequent elevation along the flanks and on the crests of high mountain ranges, which commonly have igneous masses for their nuclei or axes. The force exerted by the elastic vapours which the earth encloses in the elevation of mountains, however vast, immeasurably yields to the power indicated in the upheaval of the general surface of the land to its far inferior altitude.

Section of Crich Hill, Derbyshire.—Arched Strata.

CHAPTER II.

CONTINENTAL MASSES.

I The great eastern continent extends through upwards of two hundred degrees of longitude, from Cape Verde, the most westerly point of Africa, 17° 33′ W, to Tschuktschi-noss, or East Cape, the eastern extremity of Asia, 190° E. It embraces upwards of a hundred degrees of latitude, from Cape Taimura, otherwise called Severo Vostochni-noss, or North East Cape, in Siberia, 78° 16′ N., to Cape Lagullas, east of the Cape of Good Hope, 34° 50′ S.

The greatest northern and southern stretches of the land are made under nearly the same meridians. Compare the northern extremity of Europe, North Cape, with the southern point of Africa, Cape Lagullas: the northern and southern extremities of Asia, Cape Taimura and the peninsula of Malacca.

II. The superficial area of this mass of land is estimated at about 33,000,000 of English square miles. It has a maritime coast line of more than 50,000 miles; and attains its greatest elevation in central Asia, reaching to the enormous height of nearly five and a half miles above the level of the sea, the culminating point of the globe. Its greatest depression is the shore of the Dead Sea, which, at the water level, according to barometrical and trigonometrical measurements, is upwards of 1300 feet in perpendicular depth below the highest houses in Jaffa on the Mediterranean.

Of the three divisions of the continent, Europe comprises somewhat less than one-eighth of its entire area; Africa more than a third; and Asia more than half. Africa is more than three times, and Asia more than four times the size of Europe.

The longest straight line that can be drawn on the solid superficies of our planet, extends from Cape Verde to the western side of Behring's Strait, a distance of about 11,000 miles.

III. The south-western member of the continent, Africa, is in many respects diverse from the other portions. Externally, a comparatively unbroken coast-line; and internally, deficient water communication, with the preponderance of sandy deserts, mark the contrast. Asia and Europe exhibit repeated examples of deeply indented shores; and both are plentifully supplied with great river systems, and fertile soil.

Some remarkable structural correspondences between Asia and Europe have been pointed out by M. Boué. Each has a large central protuberance, or nucleus, bifurcated at its extremities, the spine of the respective masses.

The Himalayans of Asia and the Alps of Europe follow the same general direction. Granitoid rocks and crystalline schists compose the central parts of the chains; and the same recent sedimentary formations are found on their flanks. The narrow gorges opened by nature, which admit of the passage of the chains, and serve as thoroughfares for commerce, have precisely similar features, and are only more formidable in the case of the Himalayans. The great tertiary and alluvial valley north of the Alps, answers to Turkestan and Mongolia. Piedmont and the plain of Lombardy are a miniature likeness of the basins of the Indus and the Ganges. "Delhi," says Boué, "is Milan, Calcutta reminds us of Venice, while Bombay is the counterpart of Genoa." The vast igneous district of Hindostan has its correspondent in the volcanic zone of Italy.

The southern peninsulas of the two regions are obvious analogues, Spain and Arabia, Italy and Hindostan, the Morea and Malacca.

IV. The inferior western continent extends through upwards of a hundred and thirty degrees of longitude, from the most easterly projection of South America, below Cape St. Roque, in Brazil, 35° W., to Cape Prince of Wales, the most westerly point of North America, in Behring's Strait, 168° W. It embraces upwards of a hundred and twenty degrees of latitude, from Point Barrow in the Arctic Ocean, 72° N., to the Straits of Magellan, 54° S.

The superficial area is computed to be about 14,000,000 square miles. The sea-coast has a linear extent of 32,000 miles. The greatest elevation is rather more than $4\frac{3}{4}$ miles above the level of the sea, but nearly 3000 feet below the culminating point of the eastern continent. The longest line that can be traced passes from Point Barrow along the Rocky mountains and the Cordilleras of the Andes to the Straits of Magellan, a distance of about 10,000 miles.

V. A striking dissimilarity appears in the general contour of the two continents. In the eastern, the prevailing direction of the land is from west to east, or more correctly from south-west to north-east: in the western, it is perfectly opposite, being from north-north-west to south-south-east. The forces that raised the two masses seem to have acted at right angles to each other, in the direction of the equator in the case of the old world, and of the meridian in the instance of the new.

This statement must be somewhat modified, if we regard south eastern Asia as prolonged through the Indian and Pacific Oceans by a subaqueous continent, of which the large tracts of New Holland, New Zealand, New Guinea, Borneo, and the innumerable islands of those regions are the table lands and mountain summits.

VI. The western continent exhibits a simpler outline than the eastern. Its maritime coast has a less proportion of irregularities or indentations, no interruption of consequence occurring on the side towards the Pacific, except at California. The eastern sea-board of South America is also comparatively entire.

Of all the divisions of the globe, Europe has the most highly developed outline, being deeply invaded at all accessible points by the ocean in the form of inland seas, bays, and gulfs. This is strikingly shown by comparing the extent of their respective areas and coast lines.

	Area in square miles.	Linear miles of coast.
Europe	3,900,000	17,000
Asia	17,500,000	35,000
Africa	11,870,000	16,000
America	14,000,000	32,000

Thus, the proportion of square miles of surface to one mile of coast is in the case of Europe 229, America 437, Asia 500, and Africa 741. The figures in the table are rough approximations.

VII. Granite appears to be the base or skeleton of both continents, but while it occurs at a great elevation in the old world, forming some of the highest points of the Alps, it occupies a subordinate position among the rocks of the American mountain chains. Humboldt states that he never saw it at a greater height above the sea than 11,500 feet, and that a person might travel for years among the Andes of Peru and Quito without meeting with it at all. The superior and predominant formations of the Cordilleras are immense amorphous masses of porphyritic, basaltic, and trachytic rocks, for the most part of comparatively recent date. These volcanic products constitute a great portion of the chain, and form the loftiest summits of the new world, while in the eastern continent they occur in inferior force and never at great elevations.

From the extensive development of volcanic activity in the Andes, the newness of some of the formations, the frequency of earthquakes, and the recent rise of the western coast of Chili three or four feet above its former level, it has been inferred, that those mountains, though superior to most in elevation, are among the last that have been upheaved.

VIII. The two continents have some points of resemblance. Both terminate pyramidally towards the south. Their limits to the north have nearly the same latitude, that of 70° generally, except part of the northern Asiatic coast, which exceeds it; and an important member of each is almost isolated, a narrow isthmus connecting Africa with Asia, and uniting the Americas.

Descending to detail, we find the northerly projection of the peninsula of Jutland in Europe, repeated in the peninsula of Yucatan in central America, the only important exceptions to the southerly directions of peninsulas.

The remarkable crevices, or fiords, of the Norwegian shore, are repeated on the coast of southern Chili and western Patagonia.

IX. Comparing the two sides of the Atlantic basin, a mutual adaptation to unite may be observed in the advancing and retreating configuration of the land masses. Thus the great convexity of western Africa is opposite to the indentation of the Gulf of Mexico; and the convexity of the Brazilian shore is opposite to the indentation of the Gulf of Guinea.

The bold conception has been entertained from this peculiar outline, that the two continents once formed an undivided territory, which some great convulsion separated, creating the Atlantic valley into which the ocean poured.

X. The mean height of continents, or their elevation above the level of the sea, supposing the respective masses to be equally distributed, is a subject investigated by Humboldt with somewhat surprising results. He finds the mean height to depend, not so much on the longitudinal mountain chains—"those culminating points or domes which attract the curiosity of the vulgar"—as on the gentle but extensive and compact swellings of the plains, and the development of the table lands. Thus it is calculated, that the Pyrenees would produce upon the whole of Europe scarcely the effect of 6 feet, and the Alps about 22 feet, while the plateau of Spain, of inferior elvation but more compact, would produce an effect of 76 feet. If the vast range of the Andes were pulverised, and spread equably over the eastern plain of South America, its effect would be to raise the surface only about 518 feet. Omitting Africa, which is comparatively unknown, the final results obtained are, an elevation above the level of the sea, for Europe of 670 feet, North America 750 feet, South America 1130 feet, and Asia 1150 feet, or a mean elevation for the whole of 920 feet.

CHAPTER III.

ISLAND MASSES.

I. Islands rarely occur solitarily, surrounded by a wide expanse of ocean, but usually form groups and archipelagoes contiguous to some main shore.

Solitary isles are commonly small and of volcanic origin. Ascension Island is an example, 1450 miles from the coast of Africa, 680 from St. Helena, and 520 from the nearest point of land, the island of St. Matthew. St. Helena is another example, 1800 miles from the coast of Brazil, and 1200 from the shore of Africa, its nearest neighbour being Ascension Island. Both are volcanic formations. Rockall, a singular granite block, occurs in the north Atlantic, only a hundred yards in circumference, 290 miles from the mainland of Scotland, 260 from the north coast of Ireland, and 184 from any other land.

M. Balbi classifies a few islands placed at no great distance from one another, or a principal island surrounded by others of smaller size, as a group; and several islands, varying in their extent and distance, but in the same general locality, as an archipelago. Groups and archipelagoes have frequently detached or outlying members, which are sometimes called Sporades, or "scattered islands."

II. Some islands are simple accretions of sand, deposited by the ocean, just rising above high-water mark. Others are tracts, more or less extensive, having the same general appearances as the continents, with mountains, plains, lakes, rivers, and variable climates, being identical in geological structure with adjacent continental masses.

This affinity appears in the case of southern England and northern France. The crystalline mountains of Sardinia and Corsica, are related to the maritime Alps. Some members of the Greek Archipelago correspond to the ancient chain of Olympus and Pelion. The secondary system of the Peloponnesus appears in the isle of Crete, while Cyprus and Rhodes are geologically connected with the coast of Asia Minor. The same relationship exists between the island of Trinidad and the coast chain of Cumana; the isles of the Gulf of St. Lawrence and the adjoining continent; the Japanese islands and the deposits of Kamtchatska.

III. It is obvious, from geographical position and geological character, that such islands are continental extensions, mountain chains, and high table lands connected with the main shore, the intermediate portions, at a lower level, being submerged. In a variety of instances, appearances indicate the visible junction of continental and contiguous island masses at a former period, which violent oceanic invasions have interrupted.

It can hardly be doubted that England has in this manner been detached from the main land of Europe, the sea cutting its way through an isthmus connecting it with France, and forming the present Straits of Dover.

The West Indian islands, and those of the Indian Archipelago, seem to have been rendered insular by incursions of the ocean.

IV. A vast number of islands are volcanic, either at present the scenes of fiery convulsion, or proclaiming the past activity of the tremendous element by their igneous masses and crateriform outlines. Though widely distributed, from the island of Jan Mayen, in latitude 72°, the most northern volcanic country known to the south polar lands, they are principally found in the Indian and Pacific oceans, forming three great zones, each extending several thousand miles. The formation of new islands by submarine volcanic action is a phenomenon of the present era. Some of these remarkable creations have either entirely disappeared by subsidence, or remain as shoals slightly depressed below the surface of the ocean, while others have continued permanent.

There are well authenticated records of new volcanic islands, in the following localities:

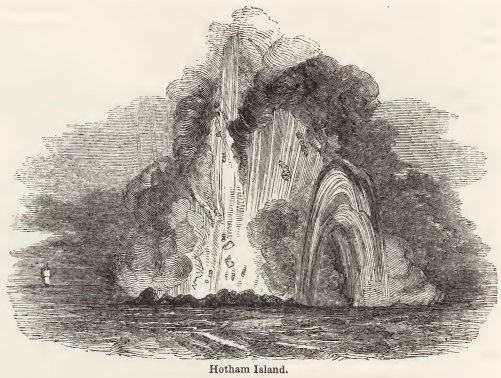
Grecian Archipelago.—In the Gulf of Santorin, one of the Cyclades, the small island of Palaia Kameni was thrown up rather more than two centuries before the Christian era. A second appeared in the year 1573, called the Little Kameni, and a third was formed in the years 1707 and 1709, called the New Kameni. They consist of lava, scoriæ, and pumice, with strata raised from the bed of the sea.

The Azores.—New islands appeared in connection with this group in 1538, 1587, and 1720; but the best known example occurred in 1811, when the temporary island of Sabrina rose off the coast of St. Michael. It attained the height of 300 feet, was about a mile in circumference, but gradually subsided, and wholly disappeared by the close of February, 1812. In 1813, there was 500 feet of water at the spot.

Coast of Iceland.—Seventy miles from Cape Reykiawas, the island of Nyöe, or New Island, was erupted in 1783, and formally claimed by the court of Denmark; but in a few months the sea regained possession of the site.

Aleutian Isles.—A new island was added to this group in the year 1806, upwards of four geographical miles in circumference; and a second appeared in 1814, which rose to the height of 3000 feet, then slightly subsiding. Both have since remained firm.

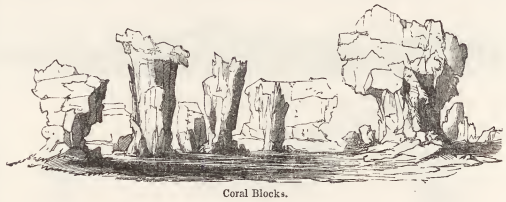
Coast of Sicily.—Thirty miles north-east of Pantellaria, in July 1831, a column of water was seen rising from the sea like a water-spout, followed by dense steam, and an island, which gained the height of 200 feet, and a circumference of three miles. Towards the close of the year, Hotham or Graham Island, as it was called, gradually subsided, and sank beneath ths waves, forming a dangerous shoal.



Hotham Island.

V. Coralline islands, among the most interesting and wonderful operations of nature, are the work of organic beings, which exist in inappreciable numbers, chiefly in the tropical seas, the Indian and Pacific oceans. They consist of the agglutinated skeletons of departed races of polypi, composed of carbonate of lime, secreted from the ocean, cemented into hard calcareous rock, and, within a certain range, of the living organisms, adding by their growth to the superstructure.

The coral insects cannot exist if left dry, or at a greater depth than from 25 to 30 fathoms. All the coral above the surface of the water is dead, and has been washed up, sometimes in huge blocks, by the stormy swell of the ocean, which has tremendous power in the Pacific. All the coral likewise is dead below the depth mentioned; and



Coral Blocks.

the fact of its occurrence hundreds of feet below the limit within which the polypi can live, with the general phenomena of the formations, is beautifully explained by Mr. Darwin's theory, that the foundations upon which the coral insects originally began to build have been in course of subsidence. This view is confirmed by the circumstance, that the lines of volcanic activity in the Indian and Pacific Oceans, or the areas of elevation, are in general remote from the spaces occupied by the coral-working insects, the supposed areas of subsidence.

VI. Coralline formations are distributed into the four great classes of Lagoon-islands, to which their Indian name of atolls is generally applied, encircling-reefs, barrier-reefs, and fringing-reefs.

1. Lagoon-islands, or atolls, consist of a belt of coral enclosing a lagoon, or vacant space of the ocean. The coral above the surface of the water is usually under a quarter of a mile in breadth, and so low, that it would not be perceptible at a very small distance, but for its vegetable clothing of cocoa-nuts and palms. The lagoons themselves, or enclosed spaces, vary in extent from a few square miles to enormous areas. Bow atoll is 30 by 6 miles across; Rimsky atoll, 54 by 20; Suadiva atoll, 44 by 34; and one of the Maldiva atolls is 88 miles long by from 10 to 20 broad. The atolls are variously circular, oval, and irregular in shape. They occur solitary and in groups, but usually in elongated archipelagoes. Dangerous archipelago, east of the Society Islands, is an assemblage of 80 atolls, mostly circular, subject to strong currents and squalls. The Low Archipelago, to the north, is an ellipse, 840 miles in its longer, and 420 in its shorter axis. The Caroline Archipelago, north of New Guinea, comprises 60 groups of atolls, about 1000 miles in length. Between the extreme limits of the Carolinas west, and those of the Low Archipelago east, there is a linear space of ocean extending upwards of 4000 miles, in which the islands are for the most part atoll-formed.

2. Encircling reefs differ only from the atolls in having one or more islands within the central expanse. The coral belt is commonly at the distance of two or three miles

from the enclosed shore. Otaheite, the principal of the Society group, is a fine example, an island rising in mountains 7000 feet high, surrounded by a lagoon, like an enormous moat, from half a mile to three miles broad, which is separated from the out-lying ocean by a reef of coral. The coral, both in the case of atolls and encircling reefs, has openings or channels in its circuit, by which ships enter the lagoons, where they find excellent harbourage.

3. Barrier reefs extend in straight lines in front of the shores of a continent, or of a large island, frequently at a considerable distance from the land. New Caledonia has a reef of this kind 400 miles long; but the grandest example of coral formation existing is the great Australian reef Externally, it starts up with little inclination from a fathomless ocean, stretches upwards of 1000 miles along the coast, varies in breadth from 200 yards to a mile, and in distance from the shore from 20 to 70 miles. There are transverse openings by which vessels enter the interior ocean, which is everywhere safely navigable. "The long ocean swell," remarks an observer, "being suddenly impeded by this barrier, lifted itself in one great continuous ridge of deep blue water, which, curling over, fell on the edge of the reef in an unbroken cataract of dazzling white foam. Each line of breaker runs often one or two miles in length, with not a perceptible gap in its continuity. There was a simple grandeur and display of power and beauty in this scene that rose even to sublimity. The unbroken roar of the surf, with its regular pulsation of thunder, as each succeeding swell fell first on the outer edge of the reef, was almost deafening, yet so deep-toned as not to interfere with the slightest nearer and sharper sound. Both the sound and sight were such as to impress the spectator with the consciousness of standing in the presence of an overwhelming majesty and power."

4. Fringe reefs are mere ribands of coral enclosing no lagoons but immediately lining the shore.

VII. In a few instances, islands have been registered as existing in certain parts of the ocean which subsequent navigators have failed to find. Saxenburg Island, and Isla Grande, both placed in the South Atlantic, are examples. Either the precise localities have not been visited, owing to inaccurate entries of latitude and longitude, so that the problem of their existence remains to be solved, or the supposed discoverers were deceived by the land-like appearance presented by low clouds and icebergs. A singular incident occurred during the recent Antarctic expedition of Sir James Clark Ross. This was the sudden appearance of what seemed to be an island, in a spot occupied a few hours before by an iceberg, upwards of a hundred feet high, the whole of the summit being perfectly free from snow. It seems that the berg had turned over unperceived from the ships, exposing to view a new surface covered with earth and stones, the mass still slightly oscillating from the effect of its capsize.

Dean's Island.

CHAPTER IV.

MOUNTAINS AND VALLEYS.

I. Mountains, to which we are largely indebted for sublime and savage, or beautiful and picturesque scenery, are the loftier protuberances of our planet, those of the first class reaching the height of 10,000 feet and upwards above the level of the sea, those of the second class ranging between that height and 4000 feet, those of the third class varying from thence to 2000 feet, the inferior elevations being styled hills and slopes.

The Himalayans, Andes, Caucasus, Alps, Atlas, Pyrenees, &c., belong to the first class: the Carpathians, Apennines, Ural, Scandinavian mountains, and some of the Scottish Highlands, &c., belong to the second; the Cumbrian and Cambrian chains, &c., belong to the third; the Malvern Hills, Peak of Derbyshire, &c., to the fourth.

The optical impression made by the elevations of the surface is that of the earth being an irregular body, and not a sphere. But the highest mountain known, rising to 28,000 feet, is only about $\frac{1}{1000}$th part of the earth's greatest circumference, and $\frac{1}{1600}$th of its axis. A grain less than $\frac{1}{50}$th of an inch in thickness would therefore represent it upon an artificial globe of twenty-one feet in circumference.

II. Though nothing appears at first sight more arbitrary and unsystematic than the contour of mountains, there is everywhere a certain general correspondence between their external aspect and internal structure. The productions of the animal and vegetable kingdoms vary with the climate, but the mineral masses present everywhere distinctive peculiarities of natural configuration.

M. Boué remarks, that while blunt cones with craters indicate volcanoes, a series of peaks like a saw denotes dolomites, a form of the magnesian limestone; rounded heads like the tops of nails characterise calcareous rocks; triangular points, slates or quartziferous schists; needles, crystalline schists; capricious twistings and crumplings, serpentines and trachytes; pyramidal forms, phonolites; thin and dark-looking walls intimate the presence of basalts or traps; rocks broken up by the weather into roundish masses are granites or grits.

III. The elevation of several remarkable localities, with some of the highest altitudes reached by man, is stated in the following list:

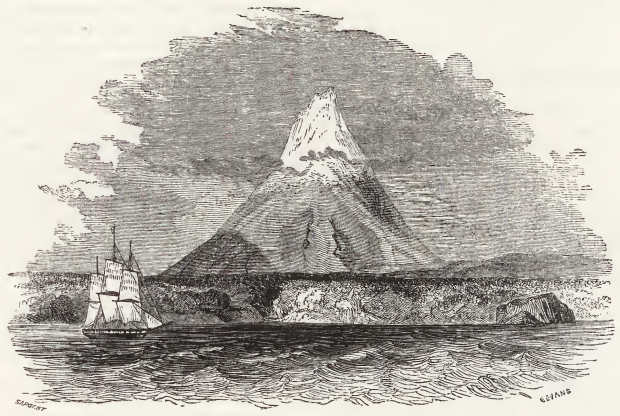
	Feet.
Culminating point of the globe, Dhawalagiri, in Nepaul	28,000
Culminating point of the western continent, Novada Sorata, Bolivia	25,250
Ascent of Gay Lussac at Paris, in 1804, being the greatest height ever attained by a balloon	22,900
Highest flight of the condor of the Andes	21,000
Highest point reached by Humboldt on Chimboraco, in 1820	19,500
Manering Pass in the Himalaya, crossed by Capt. Gerard	18,612
Culminating point of the Caucasus, Mount Elbrouz	17,796
Bushes seen in the Himalaya	17,000
Mines of Potosi	16,080
Highest pass of the Andes, in Bolivia	16,000
Good crops of wheat raised in Chinese Tartary	16,000
Highest snow line of the Himalaya	16,500
Highest snow line of the Andes	15,800
Manasa Lake in Thibet	15,000
Thick woods of pines in the Himalaya, and birch trees of a large size	14,000
Highest habitation of man in the Old World, table-land of Thibet	13,600
Highest inhabited spot on the Andes, farm of Antisana	13,435
Potosi, great square of the city	13,314
Milum Temple, near the source of the Ganges	13,000
Titicaca Lake	13,000
Culminating point of the Antarctic lands, Mount Erebus, a volcano, supposed to be	12,400
Poplars found by Gerard in the Himalaya, 12 feet in girth	12,000
Cuzco, ancient capital of Peru	11,380
Highest European Pass, that of Mont Cervin, Pennine Alps	11,100
Riobamba Pass, Andes	10,800
Highest growth of Peruvian bark	9,590
Quito, city	9,540
Pass of Sta Maria, house, highest permanent habitation of Europe	9,272
Mine of Real del Monte, in Mexico	9,120
Greatest height of the peach, apricot, and walnut, growing luxuriantly in the Himalaya	9,000
Highest carriage-road of Europe, across Mont Stelvio, Rhætian Alps	8,850
Santa Fe de Bogota, Columbia	8,650
Pass of the Grimsel, Bernese Alps	8,400
Quito, plains	8,000
Hospice, St. Bernard	7,965
Mexico, city	7,470
Mexico, plains	7,000
Hospice, St. Gothard	6,808
Highest village of Europe, Soglio in the Grisons	6,714
Source of the Loire	4,593
Culminating point of Great Britain, Ben Nevis, Inverness-shire	4,368
Plain of Ispahan, Persia	4,140
Culminating point of England and Wales, Snowdon	3,571
Culminating point of Ireland, Gurrane Tual (Magillicuddy Reeks), Kerry	3,440
Palace of the Escurial, Spain	3,264
Culminating point of England, Sca-Fell, Cumberland	3,166
Carmel, Syria	2,160
Longwood House, residence of Bonaparte, St. Helena	2,000
Rock of Gibraltar	1,439
Great Pyramid, Egypt	576
Folkstone Turnpike, Kent	575
Vienna	522
St. Paul's, London	360

IV. Mountains seldom occur completely free and insulated, that is, in plains remote from other masses. The examples are chiefly volcanic, as Mount Egmont in New Zealand. They are not often found in groups with no connection apparent between their bases. The common arrangement is for a series of neighbouring mountains to run into each other, forming parallel ridges, a number of which constitute a grand chain. The central ridge has usually the boldest development and the highest elevation; and the extremities of a chain are generally low heights, its culminating points being towards the centre. Secondary lines of mountains branch off from the main chains at various angles.

From its frequent occurrence, it seems to be a general law, for chains of mountains to have very steep declivities on one side, and very gradual slopes on the other. The Alps descend much more abruptly towards Italy than towards Switzerland. The Pyrenees are steeper towards the south than towards the north, and so is the Sierra Morena, while the mountains of the Asturias are just the reverse. The Scandinavian system is steepest towards the west and north-west; and while the Ghauts of Hindoostan have long and gentle slopes in one direction, they are precipitous on the opposite side. The Andes present a steeper face towards the Pacific Ocean than towards the main land of America.

The judgment formed from popular observation, respecting the steepness of declivities, is often most erroneous. "In the whole range of the Alps there is not a single rock which has 1600 feet of perpendicular height, or a vertical slope of 90°. The declivity of Mont Blanc towards the Allée Blanche, precipitous as it seems, does not amount to 45°; and the mean inclination of the Peak of Teneriffe, according to Baron

GEOLOGY:—CHARACTERISTICS OF THE VARIOUS MOUNTAIN RANGES.



Mount Egmont in New Zealand (Extinct Volcano.)

Humboldt, is only 12° 30′. The Silla of Caraccas, which rises precipitously from the Caribbean Sea, at an angle of 53° 28′, to the height of between six and seven thousand feet, is a majestic instance of the nearest approach to perpendicularity of any great height yet known."

V. Chains of mountains, though making many curves and angles, generally correspond in their prevailing direction, to the line of greatest length in the continent or district in which they are situated.

The chain of the Andes, prolonged in North America, under different denominations, and with frequent interruptions, extends through the longest line of the western continent, from south-east to north-west, over a linear space of upwards of 10,000 miles.

The chain which, with only a few breaks, stretches from the south-west coast of Europe to the north-east coast of Asia, comprising the Pyrenees, Alps, Balkan, Taurus, Caucasus, Hindoo-Koosh, Himalayans, &c., traverses the eastern continent in the line of its greatest extent.

The course of secondary chains, as the Apennines in Italy, the Dovre-field in Scandinavia, the Ghauts in Hindostan, &c., correspond with the greatest length of those peninsulas.

VI. Chains parallel in their course, or having identity of general direction, though remote from each other, being separated by arms of the sea, straits, or valleys, by igneous deposits, secondary or tertiary basins, exhibit correspondences in geological structure.

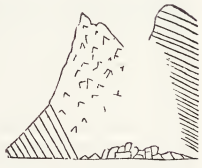
A group of parallel chains whose direction is west to east nearly, comprising the coast chain of New Granada, the Parima in South America, the range probably of Central Africa, the main chain of the Alps, the Balkan, Taurus, Hindoo-Koosh, Himalaya, Thian-Chan (Celestial Mountains), &c., closely resemble each other in geological constitution.

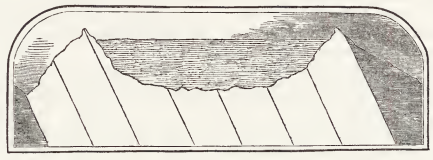
A group of parallel chains whose direction is north to south nearly, comprising ridges in the north of England, part of the Norwegian Mountains, banks of the Middle Rhine, Central France, the Ural, the Western Altai, ranges east of the Yenessei and the Lena, Cordilleras in new Mexico, Bolivia, and Chili, consist of similar ancient and transition formations, igneous deposits, metaliferous veins, and some dependent secondary strata.

VII. Those mountain chains which run in the direction of the parallels of latitude, or from east to west, are found to mark much more striking differences, not only in the flora and fauna of the globe, but among nations, than those which follow the direction of the meridians, or from north to south.

M. Boué remarks, that the immense meridional wall of the Scandinavian Alps has been no barrier to the occupancy of the country on both its sides by people connected by descent; and that in both Americas, where the meridional direction characterises all the chief chains, there is only one copper-coloured race, although the continent stretches through more climateric zones than Europe or Africa, or than Asia and Australia united. On the other hand, the comparatively feeble latitudinal barrier dividing England from Scotland, and the inferior elevations of the Highlands, have for centuries hindered the fusion of the Anglo-Saxons and the Celts, notwithstanding the close intercourse promoted by a high civilization. In like manner, the Spaniards differ more from the French than from the Portuguese, the Italians more from the Germans than the Spaniards, the Turks more from the Arabs than the Persians, &c.

VIII. The contemporaneity of parallel chains is invested with a high degree of probability; and data exist by which the relative age of different mountain systems may be estimated. The structure of a part of the Alps is exhibited in the annexed section, which shows beds belonging to the upper secondary strata uplifted and turned back by the intruding granite. The section following represents similarly recent strata, reposing horizontally on the granite rocks of Charnwood Forest, in Leicestershire. It follows that the granite of Charnwood was elevated before the deposition of the strata, and the granite of the Alps subsequent to it; and consequently the granite rocks of the English locality are of older date than





those of the Alpine. From such indications, the distinguished French geologist, Elie de Beaumont, has ranged the mountains of Europe into twelve grand distinctive systems, according to their age; which, beginning with the oldest, are as follows:

1. System of Westmoreland, comprising also mountains in North Wales and in Cornwall, the ridges of the Hundsruck, of the Eifel, and others in Nassau, with the Scandinavian Alps.
2. System of the Ballons in the Vosges, and of the Bocage in Calvados, to which belong hills in the south of Ireland and in Devonshire, elevations near Magdeburg, and probably the older part of the Hartz.
3. System of the north of England, running from the frontier of Scotland to the Midland Counties, almost direct from north to south.
4. System of the Netherlands and of South Wales, extending from Aix-la-Chapelle, traceable in an unbroken line westward to St. Bride's Bay in Pembrokeshire.
5. System of the Rhine, chiefly developed between Basle and Mayence, including a declivity of the Vosges on one side of the river, and the Black Forest on the other.
6. System of the south-west coast of Brittany, of La Vendée, of Morvan, of the Böhmerwaldgebirge, and of the Thuringerwald—the Bohemian and Thuringian forests.
7. System of the Erzgebirge, the Côte d'Or, the Mont Pilas, and the Cevennes, a closely connected group of elevations, stretching from the banks of the Elbe to the south of France.
8. System of Monte Viso; a series of ridges including the French Alps, and the south-west point of the Jura of Antibes and Nice, of which Monte Viso is the chief elevation.
9. System of the Pyrenees, to which portions of the Apennines belong, some parts of the mountains of Croatia, Dalmatia, Bosnia, Greece, and of the Carpathian range.

10. System of Corsica and Sardinia, with which the cliffs of the Loire and the Allier are classed, many chains of the Apennines, others in Istria, and Servia.

11. System of the Western Alps, stretching from Monte Rosa through Savoy and Dauphiny, in a direction from north-north-east to south-south-west, comprising the loftiest peaks of Europe near its intersection with the great chain running easterly towards Austria.

12. Principal chain of the Alps, running nearly from west to east, with the subordinate ridges on the northern side, which are parallel to it.

IX. The following Table states the length of principal mountain chains, with the heights of their culminating points:

Name.	Length in miles.	Culminating Points.	Height in feet.
Pyrenees, from the Mediterranean to the Bay of Biscay	225	Pic Nethou (Maladetta)	11,168
Apennines, from the maritime Alps west of Genoa to the southern extremity of Italy	800	Monte Corno	9,523
Alps, from Mont Blanc to the frontiers of Hungary beyond Gratz and Laybach	450	Mont Blanc	15,750
Scandinavian system, taking successively the names of Thulian, Dovre-fieid, and Koelen Mountains	900	Sneehætten	8,122
Caucasus, from the Black Sea to the Caspian, belonging equally to Europe and Asia	700	Elbrouz	17,796
Ural, common to Europe and Asia, from the Arctic Ocean to the river Ural, where it flows from east to West	1250	Deneskin Kamen	5387
Altai, forming the southern boundary of Siberia, from the affluents of the Irtish to the lake Baikal	884	Bieloukha	11,063
Thian-Chan, from the intersection with the Bolor to the centre of Mongolia	1464	——	20,000?
Kouenlun, the northern boundary of Thibet, from the Bolor chain to the sources of the Yellow River	1600	Karakorum	18,000
Himalayans, from the frontiers of China Proper, including the Hindoo-Koosh or Indian Caucasus, and the Persian Elbruz, to the south-western extremity of the Caspian Sea	2800	Dhawalagiri	28,000
Bolor-tagh, a meridional chain, prolonged from the Punjaub in lat. 32½° across the Himalaya and the Kouenlun to lat. 42½°	800	Tutucan-Mouteani	20,480
Atlas, from Cape Gher, on the shore of the Atlantic, to the Gulf of Sidra, on the Mediterranean	2000	Miltsin	11,400
Andes, from Cape Horn to the Isthmus of Panama	4550	Novada Sorata	25,250
Rocky Mountains of North America, including the Sea Alps of California and of the north-west coast	3000	Mount St. Elias	17,860

X. Humboldt has established the very remarkable law, that in a part of Asia there is a predominance of auriferous and platiniferous deposits in the mountain chains which have a meridional direction—a law which he had observed in reference to the auriferous alluvions in the American Andes, in the Southern, Alleghanies, and in the mountains of Brazil.

XI. Chains of mountains are variously intersected by valleys, which form two leading classes, termed longitudinal and transverse, from their position in relation to the course of the main elevations. The longitudinal valleys separate parallel ridges of a chain, and follow its general direction; the transverse valleys cut the ridges at right angles to it.

The canton of the Valais is a longitudinal valley, the most considerable in Switzerland, lying between the ranges of the Pennine and Bernese Alps. It extends nearly a hundred miles in length, the breadth of the base varying from a quarter of a mile to three miles, the grand heights of the Jungfrau, Finster Aar Horn, Monte Rosa, &c., forming the side walls. The transverse valleys admit chiefly of high mountain chains being crossed. In such elevated sites they are narrow and frightful gorges, styled passes and gates, because of communication being maintained through them. The passes of the Caucasus, those of the Andes, and of the Himalaya, are scenes of great magnificence—often of appalling gloom and peril. The sides of the valleys of Chota and Cutaco in the Cordilleras are 4875 and 4225 feet in perpendicular height, the breadth not exceeding 2600 feet. So deep and inclosed are the defiles of the Himalaya, that Sir A. Burnes for a considerable time could not obtain a single observation of the pole-star while journeying through them.

XI. Both longitudinal and transverse valleys, but more commonly the latter, have very often written on their opposing sides a plain record of their origin. They exhibit not only a continuation of the same strata, but salient and re-entering points so exactly corresponding as to proclaim their formation by the breakage of the general mass during its upheaval. Hence they are styled Valleys of Dislocation. Sometimes there has been upheaval without fracture, but with more effect at particular points, causing intervening depressions, which are termed Valleys of Undulation, of which an example is given from the Jura Mountains. Valleys of Denudation are those which appear to have been formed by the action of water upon soft and practicable strata; but there is little doubt that most valleys, from the grand rents of mountain ranges to the wide and gently sweeping hollows of the general surface, are mainly due to internal causes of disturbance, their physiognomy being subsequently modified by atmospheric and aqueous agencies.

Jura.

XIII. A great depression, embracing many thousands of square leagues, marks the surface of Western Asia, of which the Caspian Sea and Lake Aral form the lowest part, but which extends far into the interior of the continent, and is supposed to be intimately connected with the upheaval of the Caucasus, the Hindoo-Koosh, and the plateau of Persia. By operations directed by the Imperial Academy of Sciences of St. Petersburgh, which terminated October 23, 1837, it was ascertained that the Caspian is 83·6 English feet below the level of the Black Sea.

CHAPTER V.

PLATEAUS AND TABLE-LANDS.

I. An extensive mass of elevated land, with comparatively level sites, comes under the denomination of plateau or table-land. It may have various undulations of hill and vale, be traversed by mountain ridges, and serve as a platform for lofty peaks. But its prevailing character is that of a highly raised region on which there is a considerable area of plain surface, styled table-land from its aspect and height; the whole presenting either gradual slopes or abrupt acclivities, and sometimes terrace-shaped sides to the adjoining lowlands.

II. The principal plateaus, with their comparative mean heights, are as follows:

Plateaus of	Feet.
Spain	2240
Mysore	2944
Persia	4000
Gobi	4000
Popayan	5760
Abyssinia (Lake Tzana or Dembea)	6110
S. Africa (Orange River)	6400
Abyssinia (Axum, ancient capital)	7091
Mexico	7475
Santa Fe de Bogota	8700
Quito	9536
Bolivia (Lake Titicaca)	13,000

III. The plateau of Bolivia, or Upper Peru, remarkable for its elevation, stretches along the top of the main mass of the Andes, between the gigantic mountain knots of Cuzco and Potosi north and south, and between the Cordillera Real and the Cordillera of the Coast, east and west. The serrated ridges and smoking cones of these boundaries rise to nearly double the height of the enclosed area.—(Nevado de Chuquibamba, 21,000 feet; Gualatieri, 22,000; Nevado de Illimani, 24,200; Nevado de Sorata, 25,260.) The territory of which these are the enormous ramparts exhibits a varied surface, and extends 500 miles long by from 30 to 60 broad, comprising 150,000 square miles, upwards of twice the size of England and Wales. The lake Titicaca is about twenty times as large as the lake of Geneva, covering a surface of 4000 square miles. One of its islets, of the same name, was held sacred by the old inhabitants, and the Incas built upon it a temple of the sun; but colossal ruins in various directions are supposed to be the remains of a people anterior to their empire. Section—Map of South America.

IV. Less elevated and less extensive is the table-land of Quito, 200 miles long by 30 broad, but not less grandly situated, engirdled by magnificent heights.—(Pichincha, 15,922 feet; Cotopaxi, 18,880; Antisana, 19,137; Cayamba, 19,630, remarkable for being traversed by the equator; Chimborazo, 21,420.) "From the terrace of the government palace," says Humboldt, speaking of the city of Quito, "there is one of the most enchanting prospects that human eye ever witnessed, or nature ever exhibited. Looking to the south, and glancing along towards the north, eleven mountains covered with perpetual snow present themselves, their bases apparently resting on the verdant hills that surround the city

and their heads piercing the blue arch of heaven, while the clouds hover midway down them or seem to crouch at their feet." A peculiar and somewhat awful interest belongs to this district, if the supposition be correct that a portion of it is but the dome of an enormous vault, which has been hollowed by the action of the neighbouring volcanoes. Section—Map of South America.

V. The plateau regions of central Asia are the most extensive on the face of the globe; but more properly, the great upheaval of central Asia might be considered as forming one vast plateau, comprising different systems of table lands. Between the chains of the Thian-chan and the Kuen-lun mountains, and stretching from thence in a north-east direction to the extremity of Chinese Mongolia, is the vast district called Gobi, signifying in the Mongolian language "a naked desert." of which the Chinese denominations, Shamo, the "Sea of Sand," and Han-hai, "the Dry Sea," are the equivalents. Its mean elevation is given in the table at 4000 feet, which is the altitude of that part of it traversed by caravans of tea, about double that of the plateau of Spain; for while towards the wall of China it rises to 5800 feet, it sinks to 2400 in the central region. The length is given at about 2000 miles, with a breadth of from 200 to 300, including an area more than two and a half times that of France. Shingle, yellow sand, and gravel, form the surface, mostly overgrown with rank grass, except in the middle, where there is a belt of naked sand 20 miles across, shifting with the wind.

VI. The other principal plateaus mentioned in the table may be more briefly noticed.

Santa Fe de Bogota.—The upland plain, the site of this capital, has a perfectly level surface enclosed by a barrier of rocks. It lies along the eastern Cordillera of New Granada, at a greater height than the hospice of St. Bernard.

Mexico.—The whole interior of Mexico is occupied by a plateau, about 360 miles broad in the latitude of the city, the site of numerous lakes and extensive plains, and a platform for the colossal heights of Orizaba, Popocatepetl, Iztaccihuatl, and Nevado de Toluca, which are clothed with perennial snow.

Abyssinia and South Africa.—The central region of southern Africa appears to be an immense table land, probably of no great elevation in general, supposed to extend continuously north of the equator, terminating in the high lands of Abyssinia.

Popayan.—The elevated land occupied by the city, once the capital of New Granada, is formed by the main trunk of the Andes, which sends up in its vicinity the peaks of Purace (17,035 feet) and Nevado de Huila (17,900).

Persia.—The plateau of Iran leaves only a very narrow border of lowland along the Persian Gulf, the Indian Ocean, and the Caspian Sea. The site of Ispahan is higher than the mean elevation given; that of Teheran a trifling degree lower.

Mysore.—The table land of Mysore, in southern India, lies between the angle formed by the meeting of the eastern and western Ghauts.

Spain.—The whole central part of the peninsula consists of a series of lofty plains, divided from each other, and from the maritime lowlands, by parallel mountain chains. The plateau comprises 93,000 square miles, nearly equal to half the peninsula. Madrid is 2220 feet above the level of the Mediterranean.

VII. Parts of the plateau region of central Asia, not included in the preceding table, while more extensive, exceed the elevation of the loftiest Andean table lands; but the country has not been much explored, owing to natural difficulties, and the jealousy of oriental governments respecting the intrusion of strangers.

1. The great space between the Kuen-lun and Himalaya chains, upwards of 1300 miles long by from 350 to 400 broad, occupied by the Thibets, is a district of various but generally considerable elevation, called the Plateau of Great Tartary. At a house of the Dalai-lama, near the margin of the two lakes Manasa and Rawana-hrada, Captain Webb makes the height 14,502 feet, thus exceeding that of the high waters of Titicaca by 1600 feet. To behold the lake Manasa, an oval basin, 15 miles by 11 in extent, is deemed by the Hindoos a felicity beyond every other on earth, but prodigious difficulties attend the pilgrimage.

2. The kingdom of Ladak, comprising about 30,000 square miles, stretching along the north flank of the Himalaya, is believed by Mr. Moorcroft to have an average height of 15,845, equal to that of Mont Blanc.

3. The plateau of central Asia is walled in to the west by the Bolor chain, (Cloudy Mountains,) which forms towards the middle the remarkable region of Pamir, a radiating point in the hydrographical system of Asia, long ago correctly described by Marco Polo as a high table land. This district, locally called *Bam-i-duniah*, "Roof of the World," is the source of the Oxus, and forms the water-parting between its basin, that of the Indus, and other principal rivers. "At five o'clock," says Lieut. Wood, Feb. 19, 1838, "in the afternoon, we stood, to use a native expression, upon the *Bam-i-duniah*, or Roof of the World, while before us lay stretched a noble but frozen sheet of water (Lake Sir-i-kol), from whose western end issued the infant river of the Oxus. This fine lake lies in the form of a crescent, about fourteen miles long from east to west, by an average breadth of one mile. On three sides it is bordered by swelling hills, about 500 feet high, while along its southern bank they rise into mountains 3500 feet above the lake, or 19,000 above the sea, and covered with perpetual snow, from which never-failing source the lake is supplied." Mr. Wood found the altitude of the lake 15,600 feet, a little lower than Mont Blanc.

CHAPTER VII.

PLAINS.

I. Plains are discriminated from table-lands by being very little elevated above the sea, in some instances even descending below it. To popular apprehension the term suggests the idea of a perfectly horizontal surface, but geographically it is applied to an extent of country generally level as compared with mountainous districts, however the superfices may gently wave or prominently undulate, be studded with low hills, traversed by valleys, or intersected with deep ravines. Understood in this sense, plains constitute by far the greater portion of the earth's surface, and are the sites of its highest culture, greatest cities, and most numerous population.

The great northern plain of Europe extends through nearly 60° of longitude, from the eastern bank of the Seine to the terraces of the Ural Mountains and the waters of the Caspian Sea, and has, according to accurate measurement, nine times the surface of France. The Waldai plateau in Russia is the only principal interruptions of small dimensions and inferior elevation. This district comprehends part of Northern France, Belgium, Holland, the north of Germany, Denmark, the whole of Prussia and Poland, and the greater part of Russia. Vast areas exhibit a perfectly dead level, scarcely a rise existing, through 1500 miles, from the Carpathians to the Urals. South of the Baltic, the country is so flat that a prevailing north wind will drive the waters of the Stattiner-Haf into the mouth of the Oder, and give the river a backward flow for thirty or forty miles. The sea is only kept out of Holland by means of dykes, and towards the Caspian the surface dips below the ocean level. At Moscow, the highest point of the exclusively European plain, the elevation is only 480 feet. Pasture-land composed of the richest vegetable mould is abundant, but there are wide tracts clothed with natural forests of pine and fir, and immense quantities of waste lands, either covered with heath, or presenting bare sand, or forming swamps and morasses. The western or oceanic coast of Denmark is a continued level of marshland; and through the centre of a swamp as long as England, comprising an area of upwards of 2000 square miles, the river Pripet flows towards the Dnieper.

The great plain of Europe passes continuously round the southern extremity of the Ural Mountains, and joins the vastly more extensive lowland level of Northern Asia, which extends through 120° of longitude to Behring's Strait, between the Arctic Ocean and the Altai range. This region, comprising one-third of the whole of Asia, and surpassing by one-third the surface of the whole of Europe, is so low that at Tobolsk, 550 miles in a straight line from the Arctic Ocean, the lower portion of the town is only 128 feet above its level; and at Yakutsk on the Lena, 560 miles from the sea, the elevation is only 287 feet. At Irkutsk on the Angara, 1400 miles from the ocean in a straight line, the elevation is but 1246 feet; and the basin of the Upper Irtish, 1750 miles from the sea, or nearly 3000 following the course of the river, has been found not much to exceed 1900 feet.

In South America the plains are estimated to be to the mountainous country as four to one. A rise of only a few hundred feet in the waters of the Atlantic would completely submerge the greater part of the enormous area between its coasts and the roots of the Andes.

II. Plains, while possessing certain features in common, have characteristic peculiarities. With a view to illustrate their differences of natural condition they may be considered under their respective local denominations, as landes, heaths, and puszta, steppes, deserts, llanos, selvas, pampas, savannahs or prairies, barrens, and pine-barrens.

III. Landes, heaths, and Puszta.—Plains, for the most part infertile, known by the name of landes, occupy a large portion of the north of Germany, extending from Lower Silesia to the kingdom of Hanover, where they are prominent, and to the extremity of Jutland. They are sandy tracts, sometimes entirely naked, but more generally covered with pine-woods, or coated with the *Erica vulgaris*, which gives them the name of heaths. Fertile districts, swamps, and stagnant pools intermingle with them. In France extensive landes occur between the Gironde and the Pyrenees, vast sandy downs and levels, either wholly barren, or clothed with heath and pines, interspersed with fens and marshes, and at distant intervals with meadows and cultivated fields. The great plains of the Middle Danube, occupying the interior of Hungary, locally called *puszta*, indicate the country to have once been the bed of an inland sea or lake. They consist of tracts of rich black loam, with districts of deep sand, susceptible of cultivation; but for many miles not a tree, shrub, stone, or living creature is to be seen, the monotony of the scene being alone varied by the sand-hillocks shifting with the wind.

IV. Steppes.—The Russian term steppe is applied to the series of extensive plains which occupy south-eastern Europe, and north-western Asia. If the word implies dry and parched, it is only partially applicable to the districts it denotes. The steppes have in fact no uniform character, except that of being great lowland levels. Some are richly cultivated, while others are incapable of cultivation, but from various causes, either an excess of drought or of moisture, or the abundance of salt. Some are barren sands; others are studded with low saline plants;

others are covered with plants of the families of the compositæ and legummosæ; and others have a luxuriant gramineous clothing, woods intermingling with the pasture lands.

1. The region of the Higher Steppes extends from the river Don along the sea of Azof and the Black-Sea to the west of the Dneiper. The surface, not in general more than 200 feet above the level of the sea, exhibits barren ridges, almost treeless plains intervening, covered with coarse rank grass, and capable of producing in abundance all the cerealia.

2. The region of the Lower Steppes lies eastward of the Don, and has the Caucasus, the Caspian Sea, and the river Ural for its other boundaries. Low hills of loose shelly sand, some fertile hollows, patches covered with a saline efflorescence, pools of salt and bitter waters, are its characteristic features.

3. Passing into Asia, the steppes of the Kirghiz hordes stretch from the river Ural around the sea of Aral to a considerable distance eastward of it, comprehending nearly the whole of Turkestan. The surface is much more irregular than that of the preceding region, but in other respects similar.

4. North of Turkestan lies the great plain or steppe of Ischam, called after the river of that name, which runs through its centre and falls into the Irtish. It extends about 700 miles from west to east.

5. Farther north is the steppe of Barabinsk, hardly less extensive than the former, occupying the whole country between the Irtish and the Obi.

6. Vast marshy plains extend between the Obi and the Yenesei, and through Northern Siberia in general, where the ground is perpetually frozen to a great depth, and only superficially thawed in summer. Excluding these tracts the area of the steppes proper is supposed to be about 1,000,000 square miles.

V. Deserts.—The tracts of bare sand, gravel, rocky slabs, flints, and siliceous stones, which form deserts properly so called, condemned to eternal sterility, though not unknown in the New World, are so predominant in the old continent as to form a marked distinction between the two regions. They stretch in a nearly continuous zone of almost irretrievable desolation from the Atlantic Ocean through the north of Africa, and through Central Asia towards the Pacific. Depressions of varying extent occur, called oases, where there are wells and springs, nourishing groves of date-trees, acacias, ferns, and grasses,—fertile spots which serve as resting-places to the caravans that traverse the wilderness.

1. The most important example is the Sahara-bela-ma, "the desert without water," called also the Bahar-bela-ma, "the ocean without water," which, with the Lybian desert, separated from it by the favoured tract of Fezzan, extends 2650 miles through the central parts of northern Africa, by a breadth of from 700 to 1200 miles.

2. In addition, there are the deserts of Arabia, Mesopotamia, Persia, Independent Tartary, Afghanistan, central Asia, with similar districts in southern Africa, and sandy or stony patches in Europe. One of the most remarkable of the latter is the plain of *La Crau*, in the Bouches du Rhone, a department in the south of France. It comprises from 140,000 to 170,000 English acres, entirely composed of shingle, the stones varying in size from that of a pea to that of a pumpkin, as free from any intermixture of soil as the shingle of a sea-beach.

3. In South America, a sandy desert, called Il Gran Chaco, occurs west of the river Paraguay; a true salt desert, under the name of Las Salinas, also lies further west; and a shingle desert extends for 800 miles through eastern Patagonia. In North America, at the head of the affluents of the Missouri, a large tract of sand and gravel has received the name of the American Desert. But the Old World is emphatically the region of deserts, which occupy an extent of its surface considerably exceeding the area of the whole of Europe.

VI. Llanos.—The plains of Venezuela and New Granada in South America, chiefly on the left of the Orinoco, are termed llanos, or level fields. Often in the space of 270 square miles, the surface does not vary a single foot. A gentle wind, or a slight rise of the great river, reverses the current of its tributaries. The llanos are not quite equal to twice the extent of France. They are studded here and there with solitary palms, and undergo remarkable changes in appearance. In the wet season they are inundated for hundreds of square miles; afterwards, upon the subsidence of the waters, they are clothed with beautifully green verdure; and when the season of drought returns, the grass crumbles into dust, and the aspect of a dismal desert meets the eye.

Llanos of Badajos.

Notwithstanding a very level surface in general, there are two kinds of inequalities in the llanos:—*Bancos*, layers of sandstone or limestone, four or five feet high, which frequently extend for several miles; 2. *Mesas*, vaulted elevations, which rise so gradually as to be imperceptible except by levelling instruments, but serve as water-sheds.

VII. Selvas (forests).—The plains of the river Amazon form another division of the South American lowlands, covered with primeval woods, interspersed with clear grassy spaces and marsh lands. This zone of woods is estimated to comprise upwards of 2,000,000 square miles (as large therefore as Russia in Europe), of which there is nearly 1,000,000 of woodland, the rest being occupied by the waters and the open tracts.

VIII. Pampas.—This Indian term, signifying flats, designates the third great level region of South America, extending about 1800 miles south from the Selvas, and from the Atlantic Ocean to the Andes. It consists of treeless plains, which are in some instances sandy or saline wastes, but mostly immense beds of alluvium, covered with a strong growth of tall grass, lucerne, thistles, with gaudy flowers, presenting also vast lagoons and swamps.

IX. Savannahs or Prairies, Barrens, and Pine-barrens.—The central part of North America, from the Gulf of Mexico to the Arctic Ocean, may be called a continuous plain, estimated to contain 2,430,000 square miles. In the southern part of this tract, on both sides of the Mississippi, but principally on the west, the savannahs or prairies occur, apparently boundless meadows, of which three kinds are noticed. 1. Heathy or bushy prairies, where there are springs, nourishing, besides grass, small shrubs, grape-vines, and an infinite variety of flowers. 2. Dry prairies, the most common, having neither wood nor water, and no vegetation but grass, weeds, and flowers; called also rolling prairies, from their wavy surface. 3. Moist and well-watered prairies, abounding in pools without issue, left by the floodings of the rainy season, producing tall rank grass. The Barrens, or barren grounds, near the Alleghany and Rocky Mountains, resemble the prairies in being grassy and treeless, but are more elevated and dry. The Pine-barrens, situated on the south-coast of the United States, and also in the interior, are monotonous tracts of sand covered with gigantic pine trees.

Plains of Languedoc.

CHAPTER VIII.

FISSURES AND CAVERNS.

I. Deep narrow fissures, yawning chasms, and great chambered cavities, common in mountainous districts, are either monuments of the violent action that has shaped the external envelope of our planet, or of the extensive changes produced by slow erosion operating through a series of ages.

Clefts are frequently the beds of streams, sometimes arched over by a portion of the rock which was not rent by the convulsions that seem to have produced the fissures, forming a kind of natural bridge.

At Iconozo, in South America, on the route from Santa Fe de Bogota to Popayan, a chasm of immense profundity is crossed by a natural arch, 47½ feet in length, 39 in breadth, and 318 above the stream, Summa Paz, which passes through it. Sixty-four feet below this bridge, there is a second, composed of dislodged masses of rock, which have so fallen as to support each other. The dark abyss below is haunted by nocturnal birds, whose doleful cries increase the frightfulness of the spot. Another celebrated curiosity of this kind is the bridge which passes over Cedar Creek in Virginia, at the height of 210 feet above the water.

II. Caverns, properly so called, are perforations open to the daylight at one extremity, with lateral entrances on the sides of mountains, either presenting a single vacuity, or a series of spacious chambers connected by narrow winding passages, which often descend far below the level of the entrance.

In some instances, perforations extend completely through a mountain mass, forming natural shafts and tunnels, so straight as to allow the passage of the daylight through them.

III. True caverns are not found in the older rocks, granite, gneiss, and slate, but vertical fissures of unknown depth are not uncommon. Grand examples of cavern construction occur in ancient and modern volcanic masses. It marks also the gypsum of the new red sandstone system, and the sandstone, but is so characteristic of the mountain limestone, that the rock is sometimes called the "cavern limestone."

Fingal's Cave, in the island of Staffa, off the west coast of Scotland, occurs in pillared basalt, a structure of marvellous grandeur and beauty, to some extent due to the abrading power of the ocean.

In the curious *Grotte des Fromages*, in the basalt rocks at Bertrich-Baden, the softer parts of the basaltic columns have been so worn away, as to make them resemble piles of cheeses, and hence the name.

Surtsheller, an extensive Icelandic cavern, 40 feet high, 50 broad, and 5034 long, is in the immense lava current which has streamed from the Bald Yökul. Such cavities in recent lava currents are referable to the stream meeting an obstruction in its course, causing an overlapping of the persistant matter, and an enclosed hollow, eventually exposed at one extremity by the wearing away or falling in of the crust.

Almost all important caverns, not only in England, but in France, Belgium, Westphalia, Franconia, Wurtemburg, along the Mediterranean shores, in North America and Australia, are in limestone.

IV. From the beds of hard mud which form the floors of many dry caverns, and the streams that still run through others, as in the Peak Cavern at Castleton, it may be inferred that such cavities are due, at least to some extent, to the solvent and mechanical power of water.

Limestone caverns are remarkably characterized by calcareous formations, on the roofs, floors, and sides, caused by the percolation of water containing carbonate of lime held in solution by carbonic acid, which, becoming disengaged, the lime is deposited, originating a variety of wild, fantastic, and beautiful shapes. The depositions depending from the roofs are called stalactites; those formed on the floors from the larger drops of water that have fallen before deposition has taken place, are termed stalagmites. The descending and ascending formations are frequently seen approaching to a junction, and actually united, exhibiting a series of columns.

The localities rich in stalactites are:—1. The Blue John Mine in the Peak, a natural cavern worked as a mine for fluor spar. 2. Macallister's Cave, in the island of Skye. 3. The Woodman's Cave, in the Harz. 4. The celebrated Grotto of Antiparos, in the Greek Archipelago. 5. The extensive cave of Adelsberg, in the neighbourhood of Trieste, accessible for several miles, through which the dark waters of the Peuka flow. 6. The chambered cave of Cacahuamilpa, also several miles in length, in the *tierra caliente*, hot region, of Mexico. 7. Weyer's Cave, in Virginia.

V. Fissures of rocks occur, containing osseous breccia, (a mixture of red loam, pieces of stone, and bones,) and ossiferous caves, where, buried in mud, or covered with calcareous deposits, the separated bones of extinct species of quadrupeds have been found perfectly preserved, but in various conditions, water-worn and gnawed.

The principal of these remarkable sites are:

In England and Wales. 1. Kent's Cavern, near Torquay, in Devon. 2. Fissure

Kent's Cavern, near Torquay.

on Derdham Down, near Bristol. 3. Hutton Hole, in the Mendip Hills. 4. Caves at Oreston, near Plymouth. 5. Cave of Crawley Rocks, near Swansea. 6. Caves of Paviland, on the coast of Glamorganshire. 7. Dream Cavern, near Wirksworth, where nearly the entire skeleton of a rhinoceros was found, enveloped in mud and pebbles. 8. Kirkdale Cave, in Yorkshire, the mouth of which, long choked up with rubbish, and overgrown with grass and bushes, was accidentally discovered by workmen in 1821. Here, under a sheet of stalagmite, was a stratum of mud about a foot thick, in which lay multitudes of bones of the following animals:

Carnivora . . .	Hyæna, felis, bear, wolf, fox, weasel.
Pachydermata . . .	Elephant, rhinoceros, hippopotamus, horse.
Ruminantia	Ox, three species of cervus.
Rodentia	Hare, rabbit, water-rat, mouse.
Birds	Raven, pigeon, lark, duck, snipe.

In Germany. 1. Baümann's Hole, in the transition limestone of the Harz. 2. Scharzfeld, in magnesian limestone near the Harz. 3. Gailenreuth, Mockas, Zahnloch, Kühloch, in the Jura limestone of Franconia, near the sources of the Maine. 4. Gluchsbrunn, Leibenstein, on the south-western border of the Thuringerwald. 5. Kluterhöhle, Sundwicke, in Westphalia. The animal remains in these caverns are chiefly those of two species of bear, both extinct.

Upon the whole it may be remarked:—1. That into open fissures animals may have fallen while alive, or been drifted into them when dead, by freshwater inundations, or overflowings of the sea. 2. In the German caves, of which, in one case, that of Kühloch, the animal matter has been estimated at no less than 2,500 individuals of the cavern bear, it is likely that these animals retired through a series of ages to die, according to the habits of that tribe of quadrupeds. 3. Other caves, as that of Kirkdale, seem to have served as the den of predacious beasts, hyænas, to which they dragged the carcases of other animals inhabiting the vicinity to prey upon them. The excrement of hyænas, the teeth of young animals of that class, and bones bearing teeth-marks, resembling bones crunched by the living Cape hyæna, support this inference. 4. It is clear that animals once inhabited our northern zone, elephants, rhinoceroses, hyænas, and hippopotami, now exclusively confined to tropical latitudes.

VI. The temperature of caverns, where the roofs are massive and the openings narrow, shows little diversity, being below that of the mean of the surrounding atmosphere; but there are some which exhibit the apparent anomaly of being coated with ice in summer, which melts in winter.

Near Besançon and at Vesoul, in France; near Szelitze, in Upper Hungary; and on the south of the Ural Mountains, there are examples of these summer-produced natural ice-houses. Sir R. Murchison entered one in the latter locality, in exceedingly hot weather, and found solid undripping ice on the roof and sides, while the floor was a mass of hard snow, ice, and frozen earth. In winter, he was informed, that the temperature of the cavern is mild, while the external country is frost-bound.

The summer freezing in these moist caverns has been referred to evaporation, withdrawing the warmth from the enclosed air, and producing a degree of cold below the freezing point. But the cause is obscure. Sir John Herschel has suggested, in relation to the Ural ice-cave, that the strongly contrasted summer and winter temperature of the district may give rise to well-defined and intense waves of heat and cold; and that a summer wave of heat propagated downwards alternately with a winter wave of cold, will reach a subterranean point, at times deviating further from midsummer and midwinter, according to its depth; so that, at certain depths in the interior, the cold wave will arise at midsummer to freeze the moisture, and the heat wave in midwinter to melt the ice.

VII. Some caves, situated in volcanic regions, exhale hot and sulphurous vapours, and others are remarkable for the development of irrespirable gas.

The best known of the latter class is the Grotte del Cano, in the neighbourhood of Naples, near the Lago d'Agnano, the bed of which is the crater of an extinct volcano. This is a small cavity, ten feet deep, four broad, and nine high, on the floor of which there is a thin stratum of carbonic acid gas, elaborated by the interior chemical processes going on in that volcanic locality. It takes its name from the dogs which are placed in it by way of experiment.

VIII. Wind caverns are inexplicable phenomena. From a blowing cave in the Alleghany Mountains a hundred feet in diameter, the current of air is so strong as to keep the weeds prostrate to the distance of sixty feet from its mouth. But the most extraordinary example is the great cavern of Ouybe, of unknown extent, in Central Asia. The tempests that rush from it are sometimes so violent as to carry off everything on the road, and throw them into the adjoining lake. The wind, coming from the interior of the earth, is said to be warm in winter, and so dangerous that the caravans often stop for a whole week till the tempests have subsided.

CHAPTER IX.

GLACIAL FORMATIONS.

I. In high northern and southern latitudes, and at certain elevations in all latitudes, snow and ice occur on the surface of the globe as a permanent envelope. The causes of this physical condition, with its details, are reserved for the meteorological section, but some general remarks will here be expedient. In countries which are immediately polar, even on sites that are at the sea level, snow is permanent throughout the year, but at a much lower latitude in the southern than the northern hemisphere. Receding from the poles towards the temperate zones, it maintains firm hold of comparatively inferior elevations, while totally disappearing from the lowlands before the temperature of summer. Equidistant from the poles and the equator, or in latitude 45°, it is only permanent on mountains of considerable altitude, the lowest limit being about 8500 feet. In equatorial districts, the lowest limit of permanence rises to about 16,000 feet.

II. Apart from the regions immediately polar, the principal fields of permanent snow are: in Europe—Iceland, the Scandinavian Mountains, Alps, and Pyrenees; in Asia—the Caucasus, Himalaya (abode of snow), Kouen-lun, and Altai chains; in Africa—the Greater Atlas range; and in America—the Cordilleras.

The requisite data are wanting for an estimate of the extent of surface permanently covered with snow, but the area without the arctic and antarctic circles is comparatively inconsiderable, however locally important. The greatest masses appear to be in the Himalaya Mountains, with the connected ranges. In the Alps, the eternal snow occupies an extensive space, stretching almost continuously at one point, between the upper courses of the Rhone and the Aar, over an area of about 600 square miles. In the Scandinavian peninsula the whole region of permanent snow is computed at 3696 square miles, belonging almost entirely to Norway, remarkable for its snow plains. These are high level tracts, that of Folgefund, a projection on the south-west coast, at an elevation of 5000 feet, extending 30 miles by from 8 to 20, covered with an unbroken stratum of snow estimated at 12 yards in thickness. Out of 40,000 square miles, the supposed area of Iceland, there is an elevated region in the south-eastern quarter, estimated at 3000 square miles, covered with ice and snow.

III. The snows accumulated on the tops and steep declivities of mountains are frequently precipitated by their own weight into the subjacent valleys, rooting up forests in their course, tearing away fragments of rock, filling up beds of streams, diverting them into fresh channels, occasioning destructive floods, and sometimes burying men, cattle, and whole villages fathoms deep beneath the mass. The volume put in motion in the first instance may be small, but dislodged at a high elevation, it increases as it descends to a prodigious magnitude by forcing off other masses in its path. These avalanches, or lavanges, as they are called, are not merely fatal to life and property immediately in their way, but the air suddenly compressed by the velocity of their descent rushes off with the force of a tornado, and plays havoc with every object in the vicinity.

Avalanches are sometimes occasioned by strong gusts of wind after a heavy fall of snow in a calm state of the atmosphere, when the particles, not having acquired consistency, are driven together in vast heaps, which the declivities are not able to support. Sometimes they arise from portions of clammy snow becoming detached during a thaw, which grow in bulk like a rolling snow-ball on their passage from the superior elevations. In other cases, they are due to the melting of the snowy stratum in contact with the ground by the natural heat of the earth, which brings down the whole mass from an inclined base. Hence the three classes of drift, rolling, and sliding avalanches.

IV. Glaciers, masses of true ice, are remarkable appendages of the snow-fields, as intimately related to them as a stream to its spring, or as an icicle to a snow-covered roof. Their external aspect is that of a frozen torrent, depending upon the flanks of mountains, and extending from the higher summits into the lower valleys. Originating in the regions of eternal frost, they descend below the line of perpetual snow to the warm, cultivated grounds, where, though continually wasted, they are never destroyed, being constantly replenished from the icy world above.

Glacial ice is very different from that produced in a pond or river, less homogeneous and transparent, porous, and full of air-bubbles. The lower part of glaciers contains the most pure and solid ice; the upper part resembles frozen snow, called in French *névé*, and in German, *firn*; but most parts of every mass present an alternation of compact and transparent, with porous and semi-opaque layers.

The lower glacier of the Aar descends to the level of 5,900 feet, or upwards of 1,500 feet below the snow line of the Alps; that of Rosenlaui to 5,100; that of the Great Aletsch to 4,413; that of the Upper Grindelwald to 4,300; and that of the Lower Grindelwald to 3,400,—being upwards of 5,000 feet below the snow line. On those parts of glaciers that are below the snow line, the winter snows melt as regularly as on the surface of the adjoining land; but on those parts that are above it, the French *névé*, and the German *firn*, the snows accumulate, and form the stock from which the waste going on below is made up. In some cases, where the supply exceeds the waste, we have an advancing glacier; and where the waste is in excess, a retreating one.

The waste of glaciers from the action of the sun and rain, and the melting of the ice in contact with the ground from the natural heat of the earth, together with springs under these enormous masses, originate streams which issue forth from their extremities, frequently from caverns which their waters have scooped out, forming the sources of important rivers. The Rhone issues from the glacier of Mont Furca, and the source of the Ganges, first reached by Mr. Elliot, of the Bengal Body-guard, is a rapid stream, forty yards broad, which flows at once from a huge cave in a perpendicular wall of ice, the extremity of a glacier.

V. The size of glaciers sometimes amounts to fifteen and twenty miles in length, and three miles in breadth; the thickness at the lower end varying from eighty to a hundred feet. Their extent obviously depends upon the extent of the snow-fields of which they are offsets, and on the size and slope of the subjacent valleys. The larger masses exhibit a steep ascent at the lower extremity; they then slope gently with a surface more or less broken and undulating; and again become highly inclined towards the *névé*.

Glacier of the Rhone.

The Swiss peasants are accustomed to say that a lean snow mountain cannot produce a fat glacier. Valleys and gorges which descend to a considerable distance from extensive snow-fields, having a slightly inclined plane, enclosed on both sides with secondary ridges, are the sites that favour the formation of large glaciers. The glacier of the Aar, fifteen miles long, exhibits a difference of level amounting to only 3000 feet in that distance. The slope of that of Aletsch is 2° 58′; and that of the Mer-de-Glace of Chamouni, 3° 15′. When the slope along which a glacier descends is very steep, or it is crowded on the edge of a precipice, huge blocks of ice are frequently detached, and form destructive avalanches. The river Drance, in the Val-de-Bagnes, a wild and lonely Alpine valley, has three times been arrested in its course by accumulations of detached ice from the glacier of Getroz, forming a lake, which subsequently broke through the barrier, inundated the plains below, houses, trees, men and cattle, perishing in the resistless deluge. This was the case in the years 1545, 1595, and 1818.

VI. The general contour of glaciers is either canal-shaped, oval-shaped, or basin-shaped, according to the form of the valleys into which they protrude. The ice, when viewed in small pieces, is commonly white, like river ice; but that of the entire mass exhibits every variety of blue tinge, from the slightest cerulean to the deep hue of the *lapis lazuli*. The blue, frequently passing into green, is the deepest in the *crevasses*. No language can describe the beautiful effect of the different blue and green tints, contrasting with the pure white snow at a higher level.

Crevasses, chasms, or clefts, generally vertical in their direction, are very common, varying in width from a few inches to many feet, sometimes extending completely across the glacier, and descending to its very bottom, gradually contracting. They are supposed to be occasioned by changes of temperature in the succession of day and night, summer and winter; but the whole phenomenon is very obscure. Day-chasms and night-chasms are noticed, so called from the times in which they are said to be produced. "When I was once walking," M. Hugi states, "on the glacier of the Lower Aar, at three o'clock in the afternoon, and the weather being very hot, I heard a peculiar noise. Advancing directly towards the spot whence it proceeded, I had hardly walked thirty or forty paces before I felt that the whole icy mass trembled under my feet. The trembling soon ceased, and then began again, continuing by starts. I quickly discovered the cause. The ice was splitting and forming a chasm. Before my eyes it split suddenly over a space of twenty or thirty feet in length, so rapidly that I could not keep up with it. Then it appeared to cease, or, rather, the rent proceeded more slowly, until the trembling returned, and the splitting proceeded at an accelerated rate." While the day chasms have the wider opening at the surface of the glacier, the night chasms are inverse, the wider openings being directed towards the base.

VII. The descending march of glaciers, imperceptible to the eye, is evident from the permanence of the masses, though in the act of constant dissolution; but direct proofs of their progress have been accumulated in abundance, and the rate of motion has been ascertained. The experiments of Professor Forbes and others show decisively, that

"The glacier's cold and restless mass
Moves onward day by day,"

and not by fits and starts, though with variations as to the rate, which depend upon the seasons; thawing weather and a wet state of the ice conducing to its advancement, while cold, whether sudden or prolonged, checks its progress. The movement is the fastest in summer, by day, and during great heats; the slowest in winter, by night, and during severe frosts.

The movement of the ice of the littoral part of the Mer de Glace at Montlavert near Chamouny, attentively observed for nearly a year, was found to be as follows:

From June 29 to Sept. 28	. .	132 feet.
„ Oct. 10 to Dec. 12	. .	70 „
„ Dec. 12 to Feb. 17	. .	76 „
„ Feb. 17 to April 4	. .	66 „
„ April 4 to June 8	. .	88 „
Added for time during which no observations were taken	. .	51 „
		483 feet.

It is also found that the central parts of glaciers move faster than the sides. M. Agassiz obtained the following results, in 1841 and 1842, upon this point:

	Annual Motion.
Finster Aar.—Stake nearest the centre of the glacier	269 feet.
Stake nearest the side of the glacier	160 „
Intermediate stake	225 „
Lauter Aar.—Stake nearest the centre	245 „
Stake nearest the side	125 „
Intermediate stake	209 „

VIII. The most recent theory to explain glacial motion, that of Professor Forbes, is the best supported. Stiff and altogether rigid as the mass appears, he conceives, from careful observation of the interior structure and other circumstances, a glacier to be an imperfect fluid, or a viscous body, which is urged down slopes of a certain inclination, by the mutual pressure of its parts. He compares it to a thick mortar, or the contents of a tar-barrel poured into a sloping channel, the central parts of which would move faster than the outer edges. Bold and startling as this hypothesis appears, it best answers to observed phenomena, and seems the more probable the more it is examined.

IX. Glaciers, by their motion, break off masses of rock from the sides and bottoms of their valley-courses, and crowd along everything that is moveable, so as to form large accumulations of debris in front, and along their sides. The edges also receive the huge fragments, variously shattered by their fall, that are disintegrated by atmospheric causes; a process going on to a great extent in elevated regions.

These superficial accumulations are called *moraines*. They are of three kinds:—1. The terminal moraine, or that at the extremity of the glacier. 2. Lateral moraines; or those ridges of rubbish that lie along the sides. 3. The medial moraine, a band of fragments, which sometimes divides a glacier in the direction of its length, into two apparently distinct compartments. Suppose two glacial streams from two valleys to unite, forming a grand ice-flow in a larger valley, there would be a junction between the left hand lateral moraine of the one stream and the right hand lateral moraine of the other, forming the medial or central moraine of the united mass.

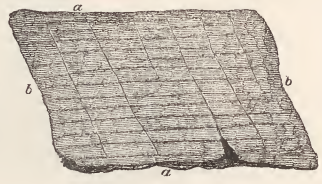
X. The base of glaciers, usually thickly set with fragments of rock, pebbles, and coarse sand, firmly frozen into the icy mass, acts as a huge rasp to the underlying rocks, scratching or striating their surfaces in moving over them; or as a smoothing and polishing instrument, if the earthy materials in the ice are finely comminuted.

In the instance of retreating glaciers, the ground, no longer occupied by the ice, exhibits debris discharged from the moraines; and large surfaces lie exposed, smoothed or striated, by the immense pressure of the moving mass.

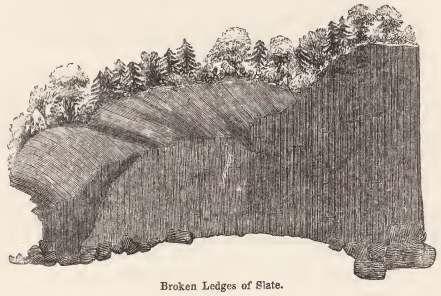
XI. The preceding facts are of great interest and importance in a geological point of view. They have been adduced to explain the phenomena of erratic blocks, of smoothed, striated, and crushed surfaces, which appear both contiguous to, and far remote from the region of existing glaciers.

1. Erratic Blocks.—Masses of rock accompanied with debris of an analogous kind, or completely insulated, the lighter debris having been removed by alluvial agency, are common, at a considerable distance from the parent rocks from which they have been abstracted. On the slope of the Jura Mountains, at the mean height of 800 feet above the Lake of Neufchatel, there is a great belt of angular blocks of granite (protogine) extending many miles, and seventy miles distant in a right line from the nearest mass of the same mineralogical character, the protogine of Mont Blanc. Some of the blocks are of enormous dimensions, the Pierre à Martin containing 10,296 cubic feet, and the Pierre à Bot 40,000 cubic feet. The plains of Prussia, Poland, and Russia, are strewed with loose detritus and colossal crystalline blocks, which have their parent bed in the Scandinavian Mountains. England and North America present many similar examples. In the latter country, the erratics are significantly called "lost rocks." According to the glacier theory, these blocks formed the moraines of ancient glaciers, borne to their present sites by the transporting power of the icy masses; and whether the theory is true or false, no mass appears too weighty for a glacier to bear along. A moving block, 80 feet long, 20 broad, and 40 high, has been seen on a modern glacier.

2. Smoothed and Striated Surfaces.—Striæ, or fine lines, accompanied with a general and often exquisite polish of the surface, the known effects of modern glacial action, are observed on rocks now apart from such agency, as the quartzose granites of the Grimsel, the limestones of Le Chaumont in the Jura, and very frequently in the United States. The cut represents an example in the latter locality, from a rock of gneiss in the neighbourhood of Boston, the lines running in the direction *a a* showing the divisions of the strata, and *b b* the striæ. These striæ, wherever found, have a general tendency to parallelism, as produced by hard fixed particles, which acted as gravers in indenting the surface.



3. Crushed and Fractured Surfaces.—In the United States, perpendicular strata of



Broken Ledges of Slate.

slaty rocks, near the summit of hills, broken and partially knocked over, as if an enormous weight had passed over them, are referred by Professor Hitchcock to glacial agency.

XII. The Glacial theory, proposed to account for these phenomena, first suggested by M. Venetz, a Swiss engineer, then advocated by M. Charpentier, and more recently elaborated by M. Agassiz, supposes an extensive development of glacial formations at a former geological epoch, converting in fact the northern regions of the globe into a vast Mer de Glace. Whatever be its difficulties, those of other theories are perhaps more numerous and formidable.

The entire elephants and rhinoceroses of Siberia, perfectly preserved in frozen mud, show that a change of climate there must have transpired suddenly from great heat to intense cold. The theory may more properly be called Glacio-aqueous, as the melting down of vast-icy accumulations, must have occasioned immense currents and deluges, officiating in the transport of materials from one site to another.

XIII. Existing glaciers occur largely in Spitzbergen and in Greenland, where, descending to the sea-level, detached masses constitute the icebergs of the Arctic Ocean, and are drifted into the Atlantic. They are not known in South America within the tropics, though the Andes rise far above the snow line. This is owing to the excessive steepness of the peaks, a feature unfavourable to their formation; but they appear in southern Chili and Patagonia. In Asia, they are found on the northern side of the Himalaya, and in the Kouen-lun, Thian-chan, and Altai. Their existence in the Caucasus and Ural Mountains is uncertain. In Europe, they occur scantily in the Pyrenees, largely in Norway and Iceland, but principally in the Alps; where, independent of the Grisons, the area of the ice is estimated at 1500 square miles, from 80 to 600 feet in thickness.

CHAPTER X.

VOLCANIC PHENOMENA.

I. The term Volcano, derived from the name which the Romans gave to their imaginary god of fire, Vulcanus, denotes a peculiar class of mountains emitting from their summits or sides molten mineral masses, with columns of flame,

Volcano of Orizaba.

smoke, and ashes. They are aptly styled in various languages Burning Mountains. A conical figure, with a cauldron-like hollow at the summit, denominated the crater or cup, is their general physiognomy.

The rocky wall of a crater is sometimes entire as a circus, but often rent. Through the rents, or by descending from the summit of the rampart, the floor may frequently be reached, exhibiting hillocks of ashes, cones of eruption, extensive fissures, and "small rounded fiery throats," through which, in times of repose, vapours of various kinds find vent, but unaccompanied with luminous phenomena. The interior of some craters is however perfectly inaccessible, owing to their vast depth, and the perpendicularity of the internal wall.

II. Most volcanoes, not extinct, emit smoke and jets of aqueous vapour at all times; but the great paroxysmal efforts occur at distant and irregular intervals. Eruptions differ in detail, but have a general resemblance. If the mountain rises above the line of perpetual snow, the approach of a crisis is indicated by its sudden melting, which occasions destructive torrents. Subterraneous sounds are heard, at first like a low prolonged moaning, gradually changed into a succession of loud detonations. Vibrations of the soil are felt, sometimes for several weeks beforehand; and as the interior war of elements is about to manifest its violence, the smoke of the hidden furnace rises in a vast, dense, black column from the crater. Unable because of its weight to ascend beyond a certain height in the atmosphere, the summit of the smoky column falls down upon itself, assuming the appearance of a gigantic pine-tree; as noticed, in the case of Vesuvius, in the younger Pliny's letter to Tacitus. Flashes of red flame, and showers of red-hot stones, like the sparks of fireworks, attended by reports as of a great train of artillery, mark the accumulated intensity of the forces at work, till the climax arrives, when mineral masses, reduced to complete fluidity, escape in fiery, majestic, and slow-winding currents from the interior. A discharge of ashes from the crater, which, borne by the air, fall upon a large area of the surrounding country, commonly terminates a grand eruption.

The products of volcanic action appear in the form of melted rock (lava); ashes, stones, and dust (scoriæ); gases and vapours.

1. Lava is chiefly composed of a very small number of minerals, felspar, augite, or hornblende, and oxide of iron, but other ingredients variously occur to modify the mass. From eighty to a hundred species of minerals have been observed in the products of Vesuvius. Raised by great mechanical pressure from an unknown depth, the melted rock ascends in the funnel of the mountain towards the summit, and sometimes, though but rarely, overflows the top, as Humboldt traced a stream to the very summit of the Peak of Teneriffe. But generally, the lava forces for itself a lateral passage through the flanks of the mountain, or issues through existing fissures, solidifying as it cools, and augmenting the diameter of the volcanic mound. Upon its first emergence, the mass has in general the consistency of honey; and hence it proceeds slowly, but sometimes it is more limpid. The surface soon cools, but the interior retains its heat, and remains semi-fluid long after the portion exposed to the atmosphere has become a hard crust. Some days after emission, lava has raised the thermometer from 59° to 95°, at the distance of 12 feet, while 3 feet off, the heat has exceeded that of boiling water. The temperature at which it remains fluid is sufficient to melt glass and silver; and to render a mass of lead fluid in four minutes, which would have required double that time to enter into fusion, if placed on red-hot iron. Nine months after eruption, in 1819, a lava current from Etna was in motion at the rate of a yard per day; and another is stated not to have been completely solidified and at rest, ten years after its emergence. But a mass of lava at Jorullo, 500 feet thick, erupted in 1759, was found smoking by Humboldt in 1804, forty-five years afterwards, and still in so heated a state that a cigar might be lighted in any of the cracks a few inches below the surface; and smoke was observed to issue from it by Burkart in 1827, though sixty-eight years after its ejection.

2. Ashes, stones, and scoriæ, ejected with considerable violence during an eruption, in clouds which darken the air for hours and even for days, have the same mineral composition as the lava. They are extricated from the liquid mass in the volcano, variously dissipated, and expelled by the explosive energy.

3. Of vapourous and gaseous products the most abundant is steam, often productive of local rains. The gases most commonly evolved are chlorine, sulphuretted hydrogen, sulphurous acid, carbonic acid, and nitrogen.

Boiling water has flowed copiously from Vesuvius during its eruptions. Discharges of water, mud, and small fishes have been observed in the case of the Andean volcanoes, but they are not to be ranked with proper volcanic phenomena. Humboldt relates, that when in 1698 the summit of Carguairazo sunk down, parts of the adjacent country were invaded with argillaceous mud containing dead fishes; and that a putrid fever which prevailed in 1691 at Ibarra, a mountain town north of Quito, was ascribed to the quantity of dead fish erupted from the volcano of Imbaburu. The fish, locally known by the name of "prenadillas," (Pymelodes Cyclopum,) abound in the subterranean reservoirs of the district, and are carried out by internal disturbance through crevices with the water and mud of the pools.

III. The amount of lava ejected in a single case of volcanic excitement is sometimes enormous. The solid contents of a current from Vesuvius in 1737, which destroyed Torre del Greco and ran into the sea, is computed at 33,587,058 feet,—equal to a cone nearly the height of St. Paul's, with a base diameter of 630 feet; but another current in 1794 was supposed to contain 46,098,766 cubic feet. The great stream from Etna in 1669, which destroyed Catania, is estimated at 93,838,590 cubic feet. But the most prodigious fiery flood on record proceeded from Skáptaa Yökul in Iceland, in 1783. The lava flowed in two nearly opposite streams, 50 miles in one direction and 40 in the other, with respective breadths of 15 and 7 miles, and with an average depth of 100 feet, but in narrow defiles amounting to 600 feet. The mass has been calculated at nearly twenty thousand millions of cubic yards, or forty thousand millions of tons, which, accumulated, would cover London with a mountain rivalling the Peak of Teneriffe.

Other volcanic products issue upon a scale of corresponding magnitude. The areas over which the winds have spread the ashes discharged indicate their quantity. Ashes from Vesuvius, A.D. 472, 473, fell in Constantinople, Egypt, and Syria; and ships were covered with them at the distance of 60 miles, in 1631. From the Souffrier Mountain, in St. Vincent's, they extended to Barbadoes in 1812; and while the sun was obscured, the streets and houses in Java were strewed with them, at a distance of 300 miles from Tomboro in Sumbawa, the point of eruption, in 1815. They were found floating in the ocean to the west of Sumatra, a distance of more than 1000 miles, forming a stratum two feet thick, through which vessels with difficulty forced their way. It was not a stream of lava from Vesuvius, but simply its ashes that destroyed the cities of Herculaneum and Pompeii.

IV. The quantity of material ejected is one criterion of the eruptive force; but a further measure of intensity is afforded by the magnitude of projectiles, with the height and distances to which they have been thrown.

A stone, 8lbs. in weight, was thrown from Vesuvius to Pompeii, a distance of 6 miles. A block of 109 cubic yards in volume was projected from Cotopaxi to the distance of 9 miles.

Sir W. Hamilton observed stones thrown out of Vesuvius so high that they occupied 11 seconds in falling; which gives a height of 2000 feet, and an initial velocity of above 350 feet in a second. During an eruption in Teneriffe, in 1798, the mountain Chahorra threw out stones which occupied from 12 to 15 seconds in their descent; which gives a height of from 2500 to 3600 feet, and an initial velocity of from 380 to 480 feet per second.

V. The degree of mechanical pressure competent to sustain a column of lava of the ordinary weight (about 2½ times that of water), so that it would overflow the craters of the respective volcanoes whose heights are given, is stated in the following Table, with the velocity with which such a pressure might eject lava at the base:

	Height in feet.	Force exerted upon the lava.	Initial velocity per second.
Stromboli	2957	179 atmospheres	371 feet.
Vesuvius	3948	314 „	496 „
Hecla	5106	413 „	570 „
Etna	10,874	882 „	832 „
Teneriffe	12,184	1009 „	896 „
Popocatapetl	17,720	1435 „	1062 „
Mount Elias	17,860	1465 „	1072 „
Cotopaxi	18,877	1492 „	1104 „

As far as relates to the eruptive force, steam-power appears to be a perfectly adequate agent, and sudden evolutions of it will explain the fits and starts of volcanic violence.

VI. The energy of volcanic action is most strikingly exhibited in the permanent rise of long lines of coast, (to be referred to hereafter), and the elevation of immense masses forming the new islands already mentioned, and new mountains.

In 1538, the Monte Nuovo was thrown up in the Neapolitan district, in 48 hours, 440 feet in height and 8000 feet in circumference.

In 1669, the Monte Rossi was thrown up on the slope of Etna, 450 feet in height and 2 miles in circumference.

In 1759, the mountain of Jorullo arose out of a plain to the west of the city of Mexico, 1695 feet in height.

Volcano of Jorullo.

VII. Volcanic ejections form an immense volume when viewed in isolation, which goes to augment the mean diameter of the earth; but its effect in this respect is still very feeble. Making a confessedly extravagant estimate of the product of eruptions from active or extinct volcanic mountains, and supposing it spread equally over the globe, the result has been calculated at only 2¼ feet for the augmentation of the diameter.

The products ejected create corresponding internal cavities, the roofs of which frequently give way beneath the weight of superficial accumulations, which subside into them. The elevating effect of volcanic action is hence very much counterbalanced by consequent subsidences. The general result is an augmentation of the heights and a deepening of the depths.

VIII. The volcanic mountains are either continuously active, or intermittent, or extinct. The frequency of eruptions, with their character, appears to be related to their height. Stromboli—a comparatively lowly mound, 2175 feet high—has been uninterruptedly active from the dawn of authentic history, a permanent fiery beacon to the sailors of the adjoining seas, but very rarely violent. The lofty cones, Etna, (10,874 feet,) Peak of Teneriffe, (12,182,) Tunguragua, (16,579,) and Cotopaxi, (18,877,) have, on the contrary, varying intervals of rest, in some instances amounting to centuries. Extinct volcanoes are those which have plainly once been the outlets of fire and igneous products, but whose activity has for ages been suspended. Some of these may really belong to the intermittent class, now experiencing a long fit of dormancy. A chart of the isle of Palma, one of the Canaries, showing the extinct crater with a side view, is annexed.

Isle of Palma.

The recorded eruptions of Etna are,—

„	„	B.C.	427—396,	„ 31 „
„	„	B.C.	396—140,	„ 256 „
„	„ between	B.C.	140—122,	four eruptions.
„	„	B.C.	122 — 56,	interval 66 years.
„	„ between	B.C.	56 & 38,	three eruptions.
„	„	B.C.	38—A.D. 40,	interval 78 years.
„	„	A.D.	40—251,	„ 211 „
„	„	A.D.	251—812,	„ 561 „
„	„	A.D.	812—1169,	„ 357 „

From this period to the present the agitations of Etna have increased in frequency and power:

Twelfth and thirteenth centuries	3 eruptions.
Fourteenth	2 „
Fifteenth	4 „
Sixteenth	3 „
Seventeenth	8 „
Eighteenth	14 „
Nineteenth to 1832	6 „

IX. By far the greater number of volcanic vents are situated in close proximity to the sea, either in islands, in chains more or less on the coast, or at the foot of

such chains. This fact, in connection with the occurrence of submarine eruptions, has often been cited in behalf of the chemical theory of volcanoes, or the hypothesis of subterranean oxidation, which refers them to the filtration of the waters of the sea into cavities containing incandescent materials, which form the fuel for eruptions. There are, however, important exceptions to the proximity of volcanoes to the sea, or to any sheet of water: some in the New World, but the most remarkable in Central Asia. Hence the position is untenable, that volcanic action depends upon the access of water to the interior regions. Humboldt conceives that coast lands are simply favourable to eruptions, because they form the sides or edges of the deep sea-basin, which, covered with strata of water, and lying many thousand feet lower than interior sites, offers less resistance to subterranean forces.

The chief inland volcanoes are at the following distances from the ocean:

Jorullo, in Mexico	81 miles.
Popocatapetl, do.	132 ,,
Sangai, in South America	93 ,,
Tolima, do.	105 ,,
Fragua, do.	156 ,,

The greatest of these distances is scarcely the tenth part of the distance of the great volcanic mountain chain of Central Asia from the sea, the Thian-chan. Towards the centre of this range, on the northern side, stands the isolated cone of Pechan, (white mountain;) and 670 miles to the east, on the southern side, is Ho-tcheon, (burning mountain,) which are both far apart from any aqueous expanse.

Distance of Pechan	from the Arctic Ocean	1530 miles.
,, ,,	from the Indus, or the Ganges	1512 ,,
,, ,,	from the east side of the Caspian	1356 ,,
,, ,,	from the Sea of Aral	336 ,,
,, ,,	from the Salt Lake of Balkhache	210 ,,
,, ,,	from the Salt Lake of Issikoul	174 ,,

X. Of all the postulates for a general theory of volcanoes, the simplest and best founded, supported by the temperature of the earth increasing with the depth in every parallel of latitude, and by the great extent of rock once fused beneath our feet, is the igneous fluidity of the interior of our planet, a vast sea of melted rock underlying the cooled and solidified crust, which may remain at rest for ages beneath enormous areas, but is liable to be locally excited and uplifted by the force of compressed vapour. Volcanic vents remind us in this view of intermittent springs.

XI. Volcanoes may be characteristically distributed into the two great classes of Central and Linear Systems; an arrangement adopted from Leopold von Buch. A Central System consists of several vents grouped around a principal cone, which serves for a common point of eruption; as those of the isles of Palma, Lancerote, and Gran Canaria in relation to the Peak of Teneriffe; or they are arranged in an expanded area, as in Iceland. A Linear System consists of several vents extending in one direction, at no great distance from each other, apparently the apertures of the same great longitudinal fissure; as the volcanoes of America and the Asiatic isles. The figures in the following Table include active and extinct volcanoes, with some of doubtful existence:

CENTRAL CLASS.

System.	No. of Vol.	System.	No. of Vol.
I. Etna (and Macaluba, Mud V. in the S.W. part of Sicily)	2	X. Tristan da Cunha Is.	1
II. Vesuvius (and Epomeo, in the I. of Ishia)	2	XI. Transverse Is.	1
III. Lipari Is.	2	XII. Trinidad I.	1
IV. Jan Mayen	2	XIII. Bourbon, Mauritius, & Rodriguez	3
V. Iceland	8	XIV. Hawaii Archipelago	4
VI. Azores	2	XV. Galapagos Is.	1
VII. Canary Is.	7	XVI. Marquesas Is.	1
VIII. Cape Verde Is.	1	XVII. Society Is.	1
IX. Ascension I.	1	XVIII. Easter I.	1
		XIX. Western Asia	3
		XX. Cutch	1

LINEAR CLASS.

System.	No. of Vol.	System.	No. of Vol.
I. Greek Is.	1	XIII. Bonin Sima Is.	2
II. Thian-chan	2	XIV. Aleutian Is.	35
III. Red Sea	3	XV. North West America	10
IV. Friendly Is.	2	XVI. Mexico	7
V. Australasia	11	XVII. Guatemala	38
VI. New Zealand	5	XVIII. Antilles	10
VII. Sunda Is.	90	XIX. Quito	17
VIII. Molucca and Philippine Is., Formosa	37	XX. Peru and Bolivia	12
IX. Japan Is.	23	XXI. Chili	22
X. Kurile Is.	18	XXII. Tierra del Fuego, and South Shetland Is.	4
XI. Kamtschatka	21	XXIII. Antarctic	2
XII. Mariana Is.	7		

The numbers in both classes amount to 424, of which only about 290 are active volcanoes, and of these 200 belong to the islands and shores of the Pacific Ocean. In no part of the globe of the same extent are there so many volcanoes as in the island of Java. Out of 90 assigned to the linear system of the Sunda Isles, 43 belong to Java.

XII. Among the specialties of volcanic action, may be enumerated, eruptions of mud, the fires of Bakou, the fire-hills and fire-springs of China, and the Geysers of Iceland.

1. Mud Volcanoes (*salsen*).—Near the ancient Girgenti, in Sicily, many conical hillocks occur, from 8 to 30 feet high, but varying at different times both in height and in form, from which there are periodic escapes of gas and of clayey mud, a rushing noise accompanying the discharge.

In Java, mud volcanoes, from 25 to 30 feet high, are described by M. Diard, discharging hot water, mixed with chloride of soda, hydrogen gas, and carbonic acid. The eruptions are attended with a subterranean noise, sometimes like thunder, heard at a considerable distance.

Near the village of Tokmali, in the district of Bakou, west of the Caspian, a remarkable eruption occurred on the 27th November, 1827. A column of fire rose to an extraordinary height, at which it continued for three hours, afterwards sinking to three feet, and burning for twenty-four hours. The fire was accompanied with an outburst of argillaceous mud, which covered a space of from 1500 to 2000 square feet, to the depth of two or three feet. Similar eruptions had before taken place, the soil, to a much greater distance, consisting of mud of a volcanic origin.

Near the village of Baklikhli, in the same district, similar phenomena occurred on the 7th of February, 1839. According to Eichwald, the jets of fire were visible at the distance of forty versts. Large lumps of earth were cast into the air, and a prodigious quantity of small hollow spheres, like small shot, was carried off by the winds, and deposited at the distance of six leagues. The spheres consisted of a black earthy calcined matter. The jets of flame continued twenty hours.

The Volcancitos de Turbaco, in South America, described by Humboldt, consist of several small truncated cones, with small apertures or craters at the top, filled with water and dark-coloured soft clay, through which air-bubbles obtain a passage. About five explosions usually take place in two minutes, a dull but rather loud sound preceding the disengagement of the air. The gas collected from the bubbles was found to be pure nitrogen.

2. Fires of Bakou.—The western peninsula of the Caspian on which Bakou is situated, is remarkable for luminous phenomena apart from its mud volcanoes. The soil is saturated with naphtha, from which inflammable gas is profusely exhaled. The *great fires*, situated about fifteen versts from the town, are not mentioned by either Greek or Roman writers, and are therefore supposed to have burst out in more recent times. The burning field is a hollow expanse, full of clefts, coated with white sand and gray dust, and abounding with particles of sulphur. Some of the clefts are seen burning, some smoking, and others emitting only vapour. The principal fire springs from shell limestone. This spot was formerly one of the most celebrated shrines of grace among the Ghebers or fire-worshippers of Persia, and a few still find their way to it even from India. The *small fires*, as they are called, in another locality, are annually extinguished by the rains.

3. Fire-springs (*Ho-tsing*) and Fire-hills (*Ho-chan*).—While there are no volcanoes in China, fire-springs occur in different parts of its western provinces, and on the borders of Thibet, far from the sea. In the *Annales de l'Association de la Propagation pe la Foi*, 1829, M. Imbert, a missionary, mentions many thousands in a space of about ten leagues long by four or five wide. They are artificial borings for the purpose of raising water, which is strongly impregnated with salt and nitre. They yield inflammable gas which burns with a blue flame, and is collected to be used in evaporating the salt water. When a torch is applied to the opening of these wells, a great stream of fire rises to the height of 20 or 30 feet with great violence and noise. In order to put out the flame, in one instance, four men placed an enormous stone upon the orifice of the well, but it was immediately projected into the air, and three of the men were injured.

The Fire-hills exhibit during the night a light like that of the aurora. In the province of Chan-si, there is a fire-mountain with a large crevice on the summit, out of which issues a powerful heat accompanied with a continual noise like thunder. In the province of Se-tchouan, the whole eastern flank of Py-kiachan is illuminated at night. The illumination is attended with no noise, but it sheds over the faces of the rocks, the tops of the mountains, the forests, trees and sky, a bright red light equal to that of the day, which disappears in the morning. It is supposed to be a volcanic flame proceeding from a deep ravine which the Chinese have not visited.

4. Geysers.—Hot-springs, common to the neighbourhood of volcanoes, occur in a remarkable group of fifty or more in Iceland, about thirty-six miles from Hecla. Some give vent to warm vapours, accompanied with very little fluid: others are filled with hot water, clear as crystal, constantly ebullient, and occasionally discharging their waters in great jets to a considerable height. Two of the latter class, called the Great Geyser, and Strokr or the New Geyser, are the principal. The Great Geyser is a circular mound of siliceous deposits, with a basin at the summit, 60 feet in diameter,

The Great Geyser.

and six or seven deep. At the bottom of the basin, there is a well or funnel, 10 feet wide at the mouth, but gradually narrowing to seven or eight, with a perpendicular descent of 70 feet. Small jets of water, rising to the height of 20 feet, take place frequently. The grand eruptions are often after intervals of a day or more. Hollow rumbling sounds and thundering explosions in the bowels of the earth announce their approach, and warn the spectator to retire to a safe distance. The water in the basin boils furiously, and is projected into the air in a succession of jets, accompanied with immense volumes of steam. The power of the Geyser varies, and the height of the aqueous columns. Mr. Lyell supposes an interior cavity, as at A, D, receiving water from the surface by the fissures F F, while steam, at an exceedingly high temperature, rises upwards by the fissures at C. The condensed steam raises the temperature of the water in the lower part of the cavity. The upper part becomes filled with steam under high pressure, which forces the water up the funnel E, B, and projects it with more or less violence at the mouth. The term Geyser, from the Icelandic *geysa*, signifies to rage, or burst forth impetuously.

CHAPTER XI.

EARTHQUAKES.

I. Earthquakes and volcanic eruptions are undoubtedly phases of the same phenomenon, now one and then the other, or both together, but at different points. The concussions so named are by far the most abundant and violent in countries which surround or lie between volcanic districts; but the shocks are most severe in places distant from active volcanic sites, the vents of the latter acting as a kind of safety-valve to the elastic force, which, when pent up, agitates the crust of the earth in effecting disengagement.

II. No phenomena are so terrible in their effects, or so fatal to the human species, as earthquakes. The volcano gives timely notice of an approaching explosion; and confines its ravages to a limited area. The lava current is readily avoided, and a safe distance from the burning mountain may speedily be reached. But the earthquake commences without the slightest warning; the shocks follow in quick succession, the first or second being usually the most tremendous; and almost at the same instant, a vast extent of country is involved in disaster from the oscillation.

Earthquake of Lisbon, Nov. 1, 1755.—The line of devastation extended from Lisbon, near the focus, north to Oporto and south to the Bay of Cadiz, a distance of 300 miles.

The area of concussion formed an ellipse, the major axis of which extended 2700 miles, from Abo in Finland to the Canary Isles.

The area of vibration, or the space through which the waters were observed to oscillate from the shock, upwards of 4000 miles in length, included a superficial extent more than four times that of Europe, comprising the lakes of Scotland, small lakes in the northern flats of Germany, springs in Hungary, the Atlantic to the West Indies, and a portion of the Canadian lakes.

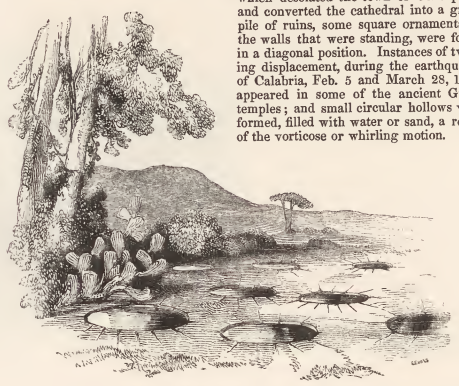
III. The movements of the ground during an earthquake are described as consisting of a series of tremulous, vertical, horizontal, or rotatory vibrations, rapidly following each other, sometimes occurring singly, or taking place together.

1. Tremblores, so called by the Creoles of South America, are tremors of the surface, common in Chili and other adjacent countries, occurring almost every day in certain seasons. Though walls are sometimes split, and objects thrown down, they are not dreaded by the inhabitants, life and property being generally secure.

2. Vertical movements, like those produced by the explosion of a mine, marked the earthquake of Riobamba, Feb. 4, 1797, which destroyed the town, and threw the bodies of many of the inhabitants upon the hill of La Culla, several hundred feet high; one of the most terrible catastrophes of physical history. Shocks acting in a perpendicular direction were experienced during the Lisbon earthquake. In a vessel far west in the Atlantic, a seaman on deck was thrown bodily upwards.

3. Horizontal movements, propagated in undulations, like waves upon water, appear to characterise every great earthquake. The undulations are estimated to travel at the rate of from twenty to thirty geographical miles in a minute.

4. Rotatory movements are rare. They are evidenced by walls being twisted round without being prostrated, and by the deflection of parallel rows of trees, and parallel ridges in the fields. After the Chilian earthquake of Feb. 20, 1835, which desolated the town of Conception, and converted the cathedral into a grand pile of ruins, some square ornaments on the walls that were standing, were found in a diagonal position. Instances of twisting displacement, during the earthquakes of Calabria, Feb. 5 and March 28, 1783, appeared in some of the ancient Greek temples; and small circular hollows were formed, filled with water or sand, a result of the vorticose or whirling motion.



GEOLOGY:—EARTHQUAKES AND THEIR PHENOMENA.

IV. Earthquakes are either linear as to the direction of the concussions, or the shocks are propagated in circles and great ellipses, gradually decreasing in intensity with the distance from the focal points.

The earthquake of Guadaloupe, Feb. 8, 1842, was felt along a right line from 60 to 70 miles in breadth, and 3000 miles in length, extending from the mouth of the Amazon into South Carolina.

The Calabrian earthquake vibrated through a circular, and the Lisbon earthquake through an elliptical area.

V. The sounds which usually form part of the phenomena vary greatly. Dull rumbling noises, and detonations like the discharges of cannon, the clanking of chains, or as if masses of obsidian and vitrified matters were struck in caverns, underground, are noticed.

Sometimes, at stations very remote, where no shock whatever has been perceived, the sounds of explosion have been heard the same instant as at the sites of catastrophe. As sound requires a definite time to be transmitted through the air, it could not, in these cases, have been propagated by that medium. Solid bodies are much better conductors of sound, baked clay transmitting it with ten or twelve times the velocity of the open air; yet the supposition of the sonorous waves being conducted by the surface of the earth, is untenable, because time is still demanded for the transport. It is likely, in such instances, that the sounds originated at such an immense depth below the surface, as to be nearly equi-distant from all the places where they were observed.

The very remarkable fact has been ascertained by Humboldt, that the dreadful earthquake of Riobamba was accompanied by no noise whatever.

The equally singular occurrence took place at Guanaxualo, a town of Mexico, remote from any volcano, of subterraneous bellowings and thunderings, *bramidos y truenos subterraneos*, being heard for more than a month, commencing Jan. 9, 1784, which caused the inhabitants to flee, yet not the slightest movement of the ground could be perceived.

VI. Earthquakes furnish the most striking examples with which we are acquainted, of the production of stupendous effects in very brief intervals. The most severe are generally the shortest in their duration.

The catastrophe which destroyed Lisbon, with sixty thousand persons, shook Europe, and rocked the waters of Lake Ontario, was over in six minutes.

The desolation of Caraccas, March 26, 1812, felt on the banks of the Magdalena, occupied less time. In the space of fifty seconds, three great shocks shattered the city, killed ten thousand of its inhabitants, and covered the province with ruins.

VII. It is popularly supposed that a direct relation exists between earthquakes and certain meteorological conditions of the atmosphere. Though such impressions may be largely fanciful, it is by no means certain that no connection subsists between subterranean and atmospheric phenomena.

Calms, long droughts, oppressive heat, with misty reddish vapours at the horizon, are believed to prognosticate earthquakes by the people of some South American districts. But Humboldt speaks of the dreaded evil arriving in all kinds of weather; of having experienced earthquakes when the air was perfectly clear, and while a fresh east wind was blowing, as well as during rain and thunder-storms.

In Northern Chili, where rain is extremely infrequent, and even weather foreboding rain, the inhabitants are firmly convinced that an earthquake is a certain herald of its fall. Mr. Darwin mentions several instances of rain following earthquakes in that region, at a period of the year when its fall is quite a phenomenon. Mr. P. Scrope remarks, to explain the connection between the two events, that when the barometer is low, and when rain might naturally be expected to fall, the diminished pressure of the atmosphere over a wide extent of country, may well determine the precise day on which the earth, already stretched to the utmost by the subterranean forces, shall yield, crack, and consequently tremble.

From a comparison of dates, earthquakes appear to be most frequent about the epochs of the equinoxes.

VIII. The phenomena of earthquakes comprise the permanent displacement of large areas of land by elevation and subsidence, the opening of extensive fissures, great oceanic waves, and a train of varying incidents dependent upon the sites and strength of the concussions.

1. Elevations.—The Chilian earthquake of 1822, which agitated the coast for 1000 miles, permanently raised it for a distance of 100 miles,—at Valparaiso, 3 feet, at Quintero, 4 feet; the greatest movement being to the north-east of Valparaiso, where beds of oysters and other shells were brought clear to the surface.

By the second great disaster of that coast in 1835, strata of clay slate in the Bay of Conception were elevated 3 or 4 feet; the land rose about a foot and a half at San Vicente, a port south of Talcahuano; and in the small island of Santa Maria the rise was estimated by Captain Fitzroy at 8, 9, and 10 feet. He found beds of putrid mussel-shells still adhering to the rocks, 10 feet above high-water mark. The inhabitants had formerly dived at low water spring tides for these shells.

2. Subsidences.—In the year 541 Pompeiopolis was half swallowed up in an earthquake; in 867, Mount Acraus fell into the sea; in 1596, the ocean covered many towns in Japan; in 1638, St. Euphemia became a lake; in 1692, Port Royal is commonly believed to have sunk; 1755, the new quay at Lisbon subsided, and its place was occupied by water 100 fathoms deep; in 1819, a town and large tracts of country were submerged at the mouth of the Indus, the Ullah Bund rising up as a compensating elevation.

3. Fissures.—Clefts radiating from a central point are frequently formed, or horizontal openings of the ground; as at Polistena in Calabria.

4. Oceanic Movements.—The neighbouring waters of the sea in a severe earthquake exhibit strong agitation: first, as observed on the west coast of America at the instant of the shock,—the waters gently rise high up on the beach, and then as quietly retire; secondly, some time afterwards the whole body of the sea retires from the coast, and then returns in a wave of overwhelming force. The great wave is sometimes half an hour after the proper catastrophe.

5. Other incidents include discharges of hot water, hot steam, irrespirable gases, mud, black smoke, flames, the landward flight of sea birds, and the strongly-marked anxiety of the animal races.

IX. Though unable to trace the intimate connection of earthquakes, volcanoes, thermal and hot waters, the disengagement of mephitic vapours, steam, and inflammable gases, it is impossible to doubt their direct relationship and mutual dependence upon one grand phenomenon—a prevailing high temperature in the interior of the earth at an unknown depth below the surface. Thermometrical experiments made in mines, show that at a certain depth the thermometer rises and goes on rising proportionably as the depth increases.

X. Humboldt finely records the peculiar impression produced by earthquakes, experienced for the first time:—"From early childhood we are habituated to the contrast between the mobile element water, and the immobility of the soil on which we stand. All the evidences of our senses have confirmed this belief. But when suddenly the ground begins to rock beneath us, the feeling of an unknown mysterious power in nature coming into action, and shaking the solid globe, arises in the mind. The illusion of the whole of our earlier life is annihilated in an instant; we are undeceived as to the repose of nature; we feel ourselves transported to the realm and made subject to the empire of destructive, unknown powers."

Fissures at Polistena.

CHAPTER XII.

LANDSLIPS AND GRADUAL DISPLACEMENTS.

I. The dislodgment of mountain masses, which fall a heap of ruins into the subjacent valleys, or simply slide to a lower level without entire derangement, is not uncommon with certain stratified formation of a loose and solvent texture. Though the work of a few moments as to the proper catastrophe, the preparing process for the event extends through a series of ages. It is in general due to the solvent power of water percolating by rents and fissures to a stratum of soft sandstone, limestone, or conglomerate, the base of other strata, and gradually carrying away its material.

No considerable derangement would ensue, but the superior strata would simply exhibit a change of level, and gradually settle upon the new base, if its plane coincided with that of the former. If, however, it should be more highly inclined, the overlying mass either slides down it or is precipitated from it with tremendous violence, according to the amount of the varying inclination.

In 1248, a part of Mont Grenier in Savoy fell, burying five parishes, and covering an extent of nine square leagues with its ruins, now called *les Abymes de Myans*.

In 1618, Mont Corno fell into the Val Bregaglia, in Lombardy.

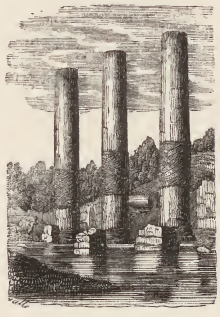
In 1714, one of the peaks of the Diablerets, or Devil's Horns, which lie on the borders of the cantons of Valais and Pays de Vaud, fell; and again in 1749, completing its destruction.

In 1806, the vale of Goldau, in the canton of Zug, with 97 houses and 484 persons, was overwhelmed by the fall of the Rossberg (Mont Ruffi).

In 1826, after violent rains following a dry season, an extensive land-slip occurred in the White Mountains, a part of the Alleghanies.

On the 20th of December, 1846, a hill, called the Bingeler Kopf, on the Rhine, which rises 380 feet above the river, gave way.

II. In addition to examples of permanent displacements of land, arising from convulsive movements, certain districts appear to be subject to slow elevation or subsidence, or to both alternately.



The pillars of the temple of Jupiter Serapis, in the volcanic district of Naples, exhibit a zone in the middle pierced by marine perforating bivalves, evidencing a long immersion in the sea, during which accumulations of rubbish probably protected the lower parts of the columns from the attacks of the shell-fish, the upper parts being above the waves. Of course the building was originally erected at a safe height from the waters. The site subsided into them, was re-elevated, and it now appears to be subsiding again at a slow rate. In March, 1819, the floor was about 6 inches above the level of the sea; in May, 1845, it was 18 inches below it at low water, and 28½ at high water.

III. On the coast of Norway from the Naze to the North Cape, and on that of Sweden along the whole west shore of the Gulf of Bothnia, raised beaches, former sea-margins, 100, 200, and even 600 feet above the present level of the ocean, chronicle a process of elevation which is still going on at the estimated rate of 4 feet in the course of a century, the maximum of the upheaving power lying

Fiord of Norway.

in North Lapland, and gradually falling off towards the south. On the contrary, South Sweden, below Sölvitzborg, is sinking; the village of Stafsten being now 380 feet nearer the Baltic than it was in the time of Linnæus, who carefully measured the distance. West Greenland also exhibits gradual depression. According to Mr. Lyell, experience has taught the aboriginal Greenlander never to build his hut near the water's edge, as ancient buildings have been slowly submerged; while the Moravians have been obliged more than once to move inland the poles upon which their large boats were set, and the old poles still remain beneath the water as silent witnesses of the change.

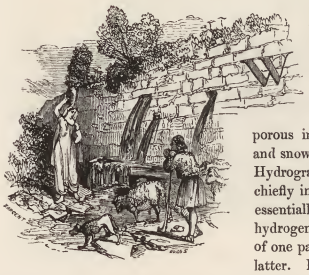
IV. Raised beaches and submarine forests, the monuments of elevation and of subsidence, occur at various points of the coast of Great Britain and other maritime countries, which have never been visited by violent earthquakes in historic times, and are far from the vents of igneous activity. There is reason for the general conclusion that while certain parts of the crust of the globe are subject to paroxysmal disturbances, it undergoes gradual expansion and contraction also, in some cases both alternately; the whole phenomena depending mainly upon different conditions of interior temperature.

Diluvial Formations.—Seen from the Acropolis of Athens.

HYDROGRAPHY.

CHAPTER I.

CHEMICAL CHARACTERS OF WATER.



WATER, one of the most important and abundant substances in nature, very widely diffused, is found in each of the three forms which bodies are capable of assuming, vaporous in the atmosphere, solid in ice and snow, and liquid in rivers and seas. Hydrographical science deals with it chiefly in the last condition. Water is essentially a compound of two gases, hydrogen and oxygen, in the proportion of one part of the former to eight of the latter. It seldom occurs however in a state of perfect purity, but variously impregnated with ingredients derived from the atmosphere, from strata in contact with it, or from decomposed and living animal and vegetable substances. Though tasteless and inodorous when pure, the foreign ingredients impart to it a peculiar taste, frequently an odour also, which the senses of man may fail to detect, but is readily observed by certain animals. At a great distance in the Desert, the scent of water is recognised by the camel.

Rain-water is the purest kind that can be collected without having recourse to distillation. It contains however a portion of carbonic acid and air, absorbed from the atmosphere; and minute quantities of iron, nickel, and manganese have been detected. Spring-water, derived mainly from rain, contains most of its ingredients, with foreign matters dependent upon the nature of the rocks through which it percolates. Large springs are commonly purer than small ones; those which occur in primitive countries, filtering through granite and siliceous rocks, are comparatively pure; but those which pass through limestone or gypsum, take up a considerable portion of these substances. River-water has its general character determined by the soil of its basin. Lake-water corresponds to that of the rivers which form it, except in the case of lakes without an outlet, which are commonly saline. Marsh-water abounds in impregnations from animal and vegetable decomposition, those members of both classes which are of the lowest grade usually flourishing in such sites. Sea-water is fully described below.

II. The water of wells, springs, rivers, marshes, and lakes, is for the most part fresh, containing no amount of saline matter appreciable to the taste, and unfitting it for domestic use. A fluid covering of this description composes a large portion of North America, its lakes comprising more than half the amount of fresh water on the face of the globe.

There must be deep subterranean reservoirs of fresh water, for it rises up in springs along the bed of the ocean. A powerful jet of this kind occurs in the Gulf of Spezzia, a branch of the Gulf of Genoa. In the bay of Xagua, on the south coast of Cuba, similar springs gush up with such force as to be dangerous to small canoes, while vessels sometimes take in supplies from them, and the lamartine, or fresh water cetacea, abounds in the vicinity. There are several other examples.

III. The amount of fresh water compared with the whole aqueous portion of our planet is utterly insignificant. The universal ocean is salt, and by a process of evaporation, a considerable proportion of our common salt is procured from its waters. A few years ago, Dr. Schweitzer, of Brighton, made a very careful analysis of the water of the English Channel, and obtained the following results:

Water	964·74372	grains.
Chloride of sodium (common salt)	27·05948	,,
Chloride of potassium	0·76552	,,
Chloride of magnesium	3·65658	,,
Bromide of magnesium	0·02929	,,
Sulphate of magnesia	2·29578	,,
Sulphate of lime	0·40662	,,
Carbonate of lime	0·03301	,,
	1000·00000	,,

IV. The oceanic waters vary in their density, or amount of saline impregnation, in different zones. Those of the southern hemisphere exceed those of the northern in saltness, while the Atlantic is in excess of the Pacific. Humboldt has concluded from good experiments, as follows:

Proportion of salt between	0°	and	14° lat.	= 0·0374
,,	,,		15° ,, 25° ,,	= 0·0394
,,	,,		30° ,, 44° ,,	= 0.0386
,,	,,		50° ,, 60° ,,	= 0·0372

It thus appears that the ocean is least dense at the equator and towards the poles, arising from the copious equatorial rains, and the melting of the polar ice.

At the same point of the ocean, the minimum of density is at the surface. This is owing to the rains. The fresh water is the lightest, and slowly commingles with the salt.

The saltness of the ocean diminishes at the mouths of large rivers. The Atlantic is only brackish 300 miles from the mouth of the Amazons. Mr. Darwin, when off the estuary of the Plata, observed how slowly the waters of the sea and the river mingled. The river-water, muddy and discoloured, from its less specific gravity, floated on the surface of the salt. This was curiously exhibited in the wake of the vessel, where a line of blue sea-water was seen mingling in little eddies with the adjoining fluid.

Inland seas are commonly less salt than the main ocean. While three pounds weight of Baltic water yield about 390 grains of salt, the same quantity taken from the German Ocean contains 747 grains. This is due to the large rivers which flow into the Baltic, draining more than a fifth of Europe, while the narrowness of the channel connecting it with the ocean only allows of a scanty influx of sea-water. The Gulf of Bothnia branch of the Baltic has the least saline impregnation, where the inflowing streams are the most numerous, and the ocean is at the greatest distance. In this gulf the water is less salt in summer than in winter, owing to the larger supply of fresh water received at that season from the melting of the winter snows. The direction of the wind has great influence upon the saltness of the Baltic. An easterly wind co-operates with the natural current to keep out the waters of the ocean: a westerly wind promotes the influx.

The case of the Mediterranean is inverse to that of the Baltic. Its water is four times salter than that of the Atlantic. The mineral character of its bed may have some effect, while the supply of water flowing into it from the ocean is larger than that of the return current, but the main cause is the excessive evaporation to which the Mediterranean is subject. Sheltered from the cold of the north by the Alps, and exposed to the heat of the African deserts on the south, its temperature is 10° or 12° higher than that of the Atlantic under the same latitude.

V. The origin of the saline quality of oceanic water is a physical question involved in obscurity. We merely know that various salts, and immense masses of rock salt, are constituent parts of the terraqueous system, a large quantity of which has come in contact with the ocean, and been dissolved by its waters. The saline ingredients render sea-water more buoyant than fresh, and, consequently better adapted for navigation, while a larger area is preserved from being ice-bound. Fresh water freezes at the temperature of 32°: salt water requires a lower temperature to be frozen, or 28½°.

VI. Besides the ocean, salt water has an extensive distribution on land, in lakes and springs, the salts occurring in a far more concentrated state than in the sea. They are common in Europe, Africa, and America, but the table lands of western and central Asia, with the adjoining steppes, constitute the great salt water lake district of the globe.

1. Salt Lakes.—The Caspian Sea, Lakes Aral, Urumiah, Toozla, Elton, and the Dead Sea occur in this region, with innumerable others of small dimensions. Some of these waters are so excessively saline as to irritate the skin. Fish cannot live in them, and if a bird dips on their surface, its wings are incrusted with salt on drying. The Lake of Toozla, in the centre of Asia Minor, nearly 100 miles in circumference, locally bears the name of Agi-gol (bitter lake), Tuz-goli (salt lake), and Tuz-choli (salt desert), the latter because its waters retreat in summer, and leave bare a thick crust of solid salt. The water of the Dead Sea, peculiarly bitter and pungent to the taste, contains a fourth part of its weight of saline matter; but that of Lake Elton, in the steppe east of the Volga, is more strongly impregnated with saline ingredients than any other known example, furnishing two-thirds of the salt consumed in Russia. Very little more than 4 per cent. of solid matter has been obtained from oceanic water; that of the Dead Sea contains 26 per cent.; and that of Lake Elton 29 per cent.

Expanses of salt and fresh water are frequently found in contiguous situations. The Lake of Urumiah, on the confines of Persia and Armenia, 300 miles in circumference, the water of which in still shallows almost forms a paste of salt, is only separated by a range of hills from Lake Van, 240 miles in circumference, renowned for its beauty, the water of which is fresh.

2. Salt Springs.—Saline mineral waters, resorted to for medicinal purposes, occur in the springs of Epsom, Cheltenham, Bath, Barèges, Buxton, Pitcaithly, and Töplitz. They have their character determined by the presence of various saline compounds,

the salts most frequently contained in them being the sulphates and carbonates of lime, magnesia, and soda, and the chlorides of calcium, magnesium, and sodium.

Pure brine springs are rare. Those in Cheshire, and some in the United States, are especially rich, and are extensively evaporated to obtain table-salt.

VII. Water appears in other mineralised forms in many localities, constituting acidulous, chalybeate, sulphureous, and siliceous springs, some of which are known to have preserved their peculiar character from very early historic times.

1. Acidulous waters are commonly associated with much free carbonic acid gas, in consequence of the escape of which they sparkle when poured from one vessel into another. They frequently contain carbonate of lime, magnesia, and protoxide of iron, because of the facility with which these substances are dissolved by water charged with carbonic acid. Examples, at Carlsbad, Seltzer, Spa, and Pyrmont.

2. Chalybeate waters are specially characterised by the presence of iron, most frequently held in solution by free carbonic acid. Examples, at Tunbridge, Cheltenham, and Brighton.

3. Sulphureous waters, readily recognised by their odour, contain sulphuretted hydrogen. Examples, at Aix-la-Chapelle, Harrowgate, and Moffatt.

4. Siliceous waters, charged with silica held in solution by free soda, are very rare, and are only found in the vicinity of volcanic or other igneous rocks. Examples, the boiling springs of the Geyser and Rykum in Iceland, and the hot springs of Pinnarkoon and Loorgootha in India.

CHAPTER II.

PHYSICAL CHARACTERS OF WATER.

I. Water appears at the surface of the globe at every temperature from the freezing to the boiling point. The mean temperature of ordinary springs is lower than that of the atmosphere of the place where they occur, if the water is derived from high-lying levels, as is commonly the case; but if it has penetrated deep into the earth, it acquires a temperature from that circumstance, which increases with the depth.

Thermal and hot waters issue from great depths, to which they have descended from the surface, and from which they are returned by hydrostatic pressure, variously affected by differing contact with the heated rocks of the interior, in some instances bringing back an insupportable temperature.

The north thermal springs of England, at Matlock, Stony Middleton, and Buxton, range from 66° to 82°, while those of the south at Bath have a higher temperature from 109° to 117°.

The thermal springs of the Alps range from 86° at Naters to 126° at Leuk.

The Ursprung at Baden has a temperature of 153½°.

The hottest permanent springs, observed by Humboldt in America, range from 204° to 207°, and flow remote from all volcanoes. Mr. Wilkes, the commander of the recent exploring expedition from the United States, observed the beach of one of the islands of the Fejee group absolutely steaming, the water oozing through the sands and gravel with a temperature of from 200° to 210°.

Thermal waters have been observed to be affected in quantity and temperature by earthquakes. The temperature of the spring of Bagnères de Luchon in the Pyrenees was raised 75°, in the year of the Lisbon earthquake, while in 1660, an earthquake which desolated the country between Bordeaux and Narbonne, caused one of the hottest of the Pyrenean springs to become so cool as to be no longer of any value.

II. The mean temperature of the ocean at the surface diminishes from within the tropics as the latitude increases, more rapidly in the southern than in the northern hemisphere, till towards the poles the sea is ice-bound. A great number of observations justify the following conclusions respecting the superficial temperature of the ocean:—1. It is generally lower at midday than that of the atmosphere, noticed in the shade. 2. It is always higher at midnight. 3. Morning and evening the two temperatures usually correspond. 4. In the usual and mean state of its surface, the ocean, from the equator to 48° of north and south latitude, is somewhat warmer than the stratum of air resting immediately upon it. 5. Banks diminish the temperature of the sea, so that it is always colder over them than where it is deeper; and the difference is the greater, the greater the shallows.

III. The following are well-supported conclusions respecting the temperature below the surface:—1. Water, being a slow conductor of heat, is less liable to sudden changes than the atmosphere, and has only its upper strata affected by seasonal influences. The temperature of the Swiss lakes often fluctuates 20° or 30° at the surface, and at the bottom no more than 3° or 4°. 2. In the ocean, the influence of seasonal vicissitudes is imperceptible at the depth of 300 feet. 3. Throughout the whole of the deep ocean, there is, at a certain depth, varying with the latitude, a stratum which maintains invariably the temperature of about 39° 5′, marking the limit of the influence of the sun's heat. 4. In equatorial seas, the line of unvarying temperature is found at the depth of 7200 feet 5. From this depth at the equator, the line gradually rises, till it comes to the surface in S. lat. 56° 26′, according to the recent determinations of Sir James Ross. It rises also to the surface at a corresponding latitude in the northern hemisphere; and here the water has the same temperature, 39° 5′, at all depths. 6. From the latitudes named to near the degree of 70, the line descends to the depth of 4200 feet, beneath which, to the greatest depths, the temperature of 39° 5′ obtains, while that of the surface is 30° 7′. Thus the temperature of the ocean decreases with the depth to a certain limit at the equator, and increases with the depth to a certain limit towards the poles.

The stratum of unvarying temperature leads to the conclusion, that the internal heat of the earth exercises no influence upon the temperature of the ocean.

IV. The oceanic warmth equator, or the line of greatest warmth at the surface, does not coincide with the geographical equator, but runs for the most part on the north of it, the ocean in the northern hemisphere being warmer than in the southern. At one point, in the Gulf of Mexico, the greatest heat is situated 28°, or about 1500 miles north of the Line.

POSITION OF THE GREATEST OCEANIC HEAT.

1. Atlantic Ocean.—The line of the greatest heat of the surface water of this ocean is entirely north of the equator, the temperature varying in different places from 77° to 88° 5′.

The minimum of 77° is near the coast of Guinea, lat. ⅓° N., long. 2° E.

The maximum of 88° 5′ is in the Gulf of Mexico, lat. 28° N., long. 89° W.

2. Indian Ocean.—The line of the greatest heat is here also in the northern hemisphere, except in the Java Sea between Sumatra and New Guinea, where it crosses the terrestrial equator, and extends along the northern shores of Java. Temperature varies from 85° 5′ to 87° 4′.

The minimum of 85° 5′ is found in the Molucca Sea, lat. 4° S., long. 129° E.

The maximum of 87° 4′ is in the Arabian Sea between Africa and India, lat. 11°. N., long. 60° E.

3. Pacific Ocean.—In the eastern portion, the warmth equator lies in the northern hemisphere: in the western portion, in the southern. Temperature varies from 81° 7′ to 88° 5′.

The minimum of 81° 7′ is found between the Galapagos and Sandwich Islands, lat. 3° N., long. 124° W.

The maximum of 88° 5′ is found in the haven of Dorerei, New Guinea, lat. 1° S., long. 134° E.

Thus the absolute greatest heat of the surface water amounts to 88° 5′, and occurs in the Mexican Gulf and Dorerei haven.

The oceanic warmth equator is traced on the Hydrographical Map, showing the currents, temperature, &c., the temperatures being expressed in full without the decimals.

V. The propagation of light through water is not carried far below the surface. Its influence at the depth of 300 feet is scarcely equal to the glimmer of twilight, and below about 700 feet there is perpetual darkness.

It has been calculated that of vertical rays only ½ advance downwards through the first 17 feet, ¼ reach 34 feet, and $\frac{1}{1000}$ penetrate to 282 feet.

VI. The waters of the globe exhibit various hues, which depend upon a variety of circumstances. The ocean absorbs all the prismatic colours except that of ultramarine, which is reflected in every direction. This is its true colour in general, when seen apart from atmospheric influence, modified by depth; but every gleam of sunshine, passing clouds, winds, shoals, and sandbanks affect its tints. Particular parts of the ocean show peculiar colours. The sea is white in the Gulf of Guinea, and black amid the Maldive Islands. Variously purple, red, and rose-coloured waters occur in the higher parts of the Mediterranean, in the Vermilion Sea off California, the Red Sea, and in tracts along the coasts of Chili, Brazil, and Australia. Green water appears in the Persian Gulf, off the Arabian coast, and in connection with the deepest blue in the Arctic Ocean. These appearances are permanent, and so distinct that ships have been seen partly in blue and partly in green water at the same time.

These tints are occasioned by differently coloured animalcules, which swarm in countless myriads in the tracts in question. The same species (*Trichodesmium erythræum*) which colour the Red Sea, have been found in other similarly tinted districts of the ocean. The green of the Arctic Seas is produced also by minute animals, which visit in spring the coast of Holland, and have been encountered in immense shoals migrating in the Atlantic. In the Antarctic regions, Sir James Ross remarked repeatedly the change of colour of the sea from light oceanic blue to a dirty brown, caused by ferruginous animalculæ.

The phosphorescence of the ocean, a magnificent and imposing spectacle, when the waves scintilate with bright green sparks, or exhibit a long line of fire, flashing in a thousand directions, is mainly caused by minute organic beings, which are phosphorescent while alive, a property retained by the gelatinous particles with which certain tracts of the deep are thickly charged,—their dead and dismembered relics. At the same time a disturbed electrical condition of the atmosphere may be most favourable to the phenomenon.

VII. Lake waters in mountain districts are frequently very transparent, and of the purest azure hue, like the lake of Geneva and the Great Bear Lake; others are intensely green, as the Lake of Zug, supposed by some to be the effect of vegetable dyes dissolved in the water; others are brown, of various shades, which may be caused by impregnation from peat mosses, or by iron oxide from the rocks; others are black, which may be the effect simply of the dark ground of their beds. River waters exhibit a similar diversity, even those that are most apart from earthy admixtures. The Ohio, Cassiquaire, and Orinoco are white; the Rio Negro, as the name implies, and the Essequibo, are black. The different hues of clear and comparatively shallow waters are perhaps generally referrable to the characters of their beds. They are observed to be light green over chalk and white sand, dark green over yellow sand, grey over mud, and brown or black over dark ground.

Cader Idris, Wales.

CHAPTER III.

SPRINGS.

I. The rains and melted snows are partly drained from the surface of high grounds into rills and streams, or returned again to the atmosphere by evaporation, or devoted to the purposes of animal and vegetable life. But a large portion is received into the soil by minute absorption, or percolates through cracks and fissures in the rocks, pursuing a downward course till arrested by clays and impermeable strata, where the water accumulates, and is forced by hydrostatic pressure to find its way again to the surface, occasioning the phenomena of natural springs. Artificial springs, called Artesian Wells, from the province of Artois in France, the ancient Artesium, where they have been long in use, are constructed upon the principle of the natural.

Artesian Well

Suppose A A a bed of clay or mass of rock, impervious to water, the site of a town; B B a stratum of sand or sandstone, through which it readily passes, cropping out from beneath A A on each side; C C also an impervious stratum. Rain falling upon B B where it crops out, and absorbed by it, yet prevented from passing downward under the action of gravity by C C, will travel laterally through the pervious stratum and completely saturate it. In this condition, if the superincumbent rock A A is bored at W, the water of B B will rise through the vent to the surface, because the water-bearing stratum at both its prolongations is at a higher level than that of the point where the boring is made. The hydrostatic pressure is sometimes so great as to cause the water to rush up impetuously, forming jets 40 or 50 feet high.

Artesian wells may fail, either because no water-bearing stratum is reached, or because that stratum does not rise high enough above the place to bring the water to the surface.

II. Some springs are perennial or constant, discharging a great volume of water, and a few show no diminution in seasons of the longest drought. These are quite independent of the last showers that fall, though primarily derived from rain and melted snow, which originate bodies of water in subterranean reservoirs, so vast as not to be exhausted before they are replenished.

III. Other springs are intermittent, depending entirely upon the prevailing character of the season. They gush abundantly after heavy rains; flow feebly, and completely fail in continued dry weather. Valleys in the chalk downs of the south of England have numerous and copious springs during one part of the year and are dry in another.

IV. Reciprocating springs, or those which ebb and flow at short intervals, with somewhat of a character of periodicity, are rare; but to this class belong the Ebbing and Flowing Well of the Peak, and the far-famed Pool of Siloam.

The explanation commonly received, though it does not account for all the phenomena, supposes an interior cavity as A, discharging itself by a syphon-formed channel, B C D. At a particular moment, when the water in the cavity is sufficiently high, it overflows the level of C, and runs out, the current ceasing till the supply has raised the water again to the vertex of the syphon-formed arch.

On some of the low islands in the West Indies, and on Keeling Island in the Indian Ocean, there are wells which regularly ebb and flow with the tide. The compressed sand, or porous coral rock, is permeated like a sponge with the salt water of the ocean. It does not mix with the fresh water in the wells derived from the surface rains, but forms a stratum beneath it,—the whole rising and falling with the tides.

CHAPTER IV.

RIVERS.

RIVERS have their origin in springs, a number of which commonly unite their waters to form a stream, so that it is difficult to single out the head fountain; or they flow from lakes; or have their source in the melting of glacial ice and snow. They are important auxiliaries to civilization, as means of communication between inland nations, and channels of commerce, rendered vastly more efficient in these respects since the discovery of steam navigation, which, overcoming the power of the current, admits of the most rapid floods being readily ascended. Rivers are either oceanic or continental.

Oceanic rivers are those which flow into the sea. 1. The Arctic Ocean receives several grand contributions, the Obi, Yenesei, and Lena from northern Asia, the Mackenzie from North America, rivers of the first class, but impaired in their utility by their lower courses being frozen up for long periods and their mouths being almost constantly encumbered with ice. 2. The Indian Ocean has principal rivers in the Ganges, Bramahpoutra, Irawady, Indus, and Euphrates. 3. The Pacific Ocean, considering the vast extent of its basin, has few river contributions. None of importance

enter it on the American side, but the Columbia and Colorado, but eastern Asia discharges into it the great systems of the Amour, Yang-tse-Kiang, Hoang-Ho, Si-Kiang Meinam, and Camboja. 4. The Atlantic Ocean has the mightiest river-floods of the globe in direct or indirect communication with it; all the leading rivers of Europe except the Dwina; the Nile, Senegal, and Niger from Africa; the St. Lawrence, Mississippi, Orinoco, Amazon, and La Plata from America.

Continental rivers are those which never reach the ocean, but disembogue in lakes that are unconnected with it, or are absorbed and lost in sandy deserts. The Volga, Ural, and Kour terminate in the Caspian; the Sir, or Sihoun, the Amu, or Gihon (ancient Oxus), flow into Lake Aral; the Jordan enters the Dead Sea; and a great number of small streams in western and central Asia either end in lakes, or are lost in their own sands. This appears to be the case also in interior Africa, and many similar examples occur in America.

The Rio Grande, which rises on the table land of Mexico, is lost in Lake Parras after a course of 300 miles; and the Rio Desaguadero, which flows from Lake Titicaca on the Bolivian plateau, is lost in lakes and swamps after a course of about the same extent.

II. The hydrographical region of a principal river, or its basin, includes, besides the bed actually occupied by the water, the whole of the declivities from which its tributaries descend, or the entire country drained, which is defined by an imaginary line passing through the sources of its feeders. Each affluent, and each rill flowing into it, has a basin peculiar to itself, defined in the same manner, their united areas constituting the basin of the grand stream.

The greatest river-basins are in America; the least in Europe.

III. The country which divides one basin from another is called the water-parting, the drainage from thence being in different directions, of which the ridge of a house-roof affords a rough illustration. This is sometimes a lofty range of mountains, as the Alps, the water-flow from thence being through the Rhine to the German Ocean, through the Danube to the Black Sea, through the Rhone to the Gulf of Lyons, and through the Po to the Adriatic. But very commonly a water-parting has no great elevation, a slight convexity sufficing to separate one river-basin from another, and produce distinct systems of drainage.

In the east of Europe, the water-parting, commencing at a spur of the Carpathian Mountains and extending to the Waldai heights, a distance of 600 miles, is formed by very slight elevations on the great plain of Russia, separating the systems of the Vistula and Niemen, from those of the Dneister and Dnieper, which respectively flow to the Baltic and Black Seas.

IV. Where the water-partings are low, rivers are largely united in civilised countries by canals promoting navigation; or, as in Canada, barges are carried across the intervening country at points favourable for the transport; but there are examples of river-basins so running into each other as for water communication to subsist naturally between two primary streams. The most remarkable case of this kind, long deemed to be impossible by physical geographers, is the bifurcation of the Orinoco.

In the plain of Esmeralda, the Orinoco, there running west, sends off a branch to the south, the Cassiquiare, which joins the Rio Negro, one of the leading affluents of the Amazons, and thus connects the two primary rivers. The Cassiquiare is 100 yards wide where it leaves the Orinoco, and 550 where it falls into the Rio Negro after a course of 180 miles. Humboldt, in 1800, satisfactorily ascertained this fact, by passing along the natural canal from the one river to the other. There are other instances, but they are very rare. We give a translated copy of Humboldt's map of the Orinoco, exhibiting its bifurcation.

V. The course of rivers is in general very tortuous; an apparent disadvantage, as it increases the time necessary for their navigation, but hereby a larger area of country is furnished with the means of inter-communication, and that velocity of the current prevented which would render navigation altogether impracticable.

The amount of meandering in some principal rivers, including that of their tributaries, or the difference between the direct distance from sources to mouths, and that by the channels, is given approximately in the annexed Table:

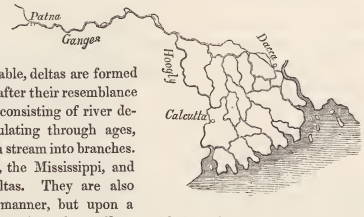
Rivers.	Meandering.
Rhine	240 geog. miles.
Elbe	340 „ „
Rhone	352 „ „
Dnieper	532 „ „
Don	552 „ „
Danube	616 „ „
Ganges	856 „ „
Indus	864 „ „
Euphrates	892 „ „
La Plata	892 „ „
Nile	920 „ „
Orinoco	984 „ „
Lena	1004 „ „
Obi	1044 „ „
Mackenzie	1156 „ „
Hoang-Ho	1160 „ „
Volga	1440 „ „
Amazon	1562 geog. miles.
Yenesei	1572 „ „
Mississippi—Missouri	2148 „ „

VI. The form of the channel, the slope of the bed, and the volume of water, are the elements upon which the velocity of rivers depend. If the banks offered no obstruction, and the molecules of water were not checked by friction with the sides and bottom of the bed, the accelerating force of gravity would convert gently flowing streams into irresistible torrents, perfectly impassable to the inhabitants of the opposite banks.

It has been calculated, in the circumstances supposed, that the Thames would flow at the rate of 50 miles an hour, while the Rhone would rush at the whirlwind speed of 164. The fall of the Thames is only 376 feet: that of the Rhone 900 from the point where the great body of its waters are received, but 4540 feet from its source. The entire fall of the Danube is 2850 feet: the Elbe 4000: the Rhine 7650: the Ganges 13,672 feet. The principal part of the fall of rivers occurs in the upper portions of their course where they are mountain torrents. Of any extensive river, the Volga has the least fall, 633 feet, from its source on a slope of the Waldai heights, at an elevation of 550 feet, to its entrance into the Caspian, which is 83 feet below the level of the ocean,—a direct distance of 900 miles, but 2400 miles including the meanderings.

When water has once received an impulse by following a descent, the simple pressure of the molecules upon each other is sufficient to keep it in motion long after its bed has lost all inclination, the pressure and the rate of motion being proportionate to its volume. The Amazon falls only 4 yards in the last 700 miles of its course, or $\frac{1}{4}$th of an inch in $1\frac{1}{4}$ miles; and for 400 miles from its estuary, the Plata has only a descent of $\frac{1}{33}$rd of an inch a mile.

VII. The alluvial soil transported by great streams is gradually deposited as the current slackens. Where the coasts are flat, and the quantity of solid matter brought down considerable, deltas are formed at their mouths, called after their resemblance to the Greek letter Δ, consisting of river deposits, silently accumulating through ages, and cutting up the main stream into branches. The Ganges, the Nile, the Mississippi, and others, have large deltas. They are also formed in the same manner, but upon a smaller scale, at the junction of an affluent with its primary, and at the confluence of a river and lake.



The water of the Ganges, according to Rennell, yields about one part in four of sediment. He estimates the mean quantity of water discharged throughout the whole year at 80,000 cubic feet in a second, but when the river is in flood, the quantity is 405,000 cubic feet in a second. These data lead to the conclusion, that there daily passes down in the flood seasons, a mass of matter equal to 74 times the weight of the Great Pyramid of Egypt. The Hoang-Ho, which traverses the great alluvial plain of China, is supposed to bring down in one hour 2,000,000 cubic feet of earth.

Many rivers have no deltoid formations, owing to not traversing alluvial plains, or to lofty coasts lying around their confluence with the ocean, or strong lateral sea-currents bearing off the sediment to distant parts of its own bed. They empty themselves by a single channel, broad, deep, and unobstructed, in which large navies may ride. This circumstance gives importance to many rivers of inferior order, as the Tagus and the Thames.

VIII. Rivers are subject to changes of level, which are either irregular or periodical, according to the nature of the producing cause. The irregular alterations are the effect of casual heavy rains, which temporarily convert insignificant streams into vast floods—of which a remarkable example occurred in Scotland in 1829, in the case of the Nairn, Spey, and Findhorn; or they are occasioned by peculiar winds. A strong easterly wind causes a rise in the St. Lawrence, which is unaffected in its level by either rains or drought, while it causes a rise of 6 feet in the eastern waters of Lake Erie. In a similar manner, a strong westerly wind blowing from the Gulf of Finland acts as a dam to the waters of the Neva. On the 26th of November, 1838, the water failed so completely in the Clyde, Nith, and Teviot, that the mills were stopped eight hours along the lower parts of the streams, owing to the coincidence of a gale of wind and a strong frost, which congealed the water near their sources. A sheet of water ten miles broad, and generally only three feet deep, has, by a strong wind, become six feet deep on one side, while the windward side was laid dry. The periodical changes in the level of rivers are diurnal, semi-annual, and annual.

Rivers which fall into tidal seas have the level of their lower course daily varied by the tidal wave for some distance, depending upon the strength of the tide, the breadth and shape of the river-channels, and the force of their currents. The wider and more direct the bed of a stream the further the tide will penetrate, other circumstances

being equal, while a narrow sinuous course offers obstructions to its progress. The tide is perceptible about 70 miles in the Thames, 576 in the Amazon, and 255 in the Orinoco. The upper course of streams which immediately descend from snow mountains exhibits diurnal variation, the heat of the sun producing high water every day by melting the snow, the increase being the greatest in the hottest days.

Semi-annual and annual variations distinguish the rivers of tropical regions, and of countries bordering on the tropics. They are the effect of regular seasonal changes, which occur at exactly opposite periods, north and south of the equator.

The Tigris rises semi-annually, first and most remarkably in April, owing to the melting of the snow on the Armenian Mountains: secondly, in November, from periodic rains. The Mississippi rises twice in the year, first, about January, in the lower part of its course from periodic rains; but the grand flood, which affects the entire stream, commencing in March and continuing till June, is caused by the melting of the snow in the high latitudes in which its sources lie.

The most remarkable river-inundations are annual, and are the effect of seasonal rains. The flood of the Orinoco is at its greatest height in August, extending 600 miles in length, and from 60 to 90 in width, covering the savannahs to the depth of 12 or 14 feet. Those of the Ganges, Niger, and Gambia, attain their full elevation about the same period. On the contrary, the Amazon, south of the equator, begins to rise in December, is at its greatest height in March, and its least in July and August.

IX. A slope of 1 foot in 200 in the bed of a river renders it unnavigable; a greater inclination produces a rapid; and one still greater, approaching the perpendicular, a cataract. Rapids occur in most principal rivers, the navigation being carried on by the transport of barges along the banks, or by artificial canals, but in some instances they are surmounted by the aid of the tide. The rapid of Richelieu, in the St. Lawrence, between Quebec and Montreal, appears and disappears with the ebb and flow of the tide, the water rising fifteen or eighteen feet temporarily removes the obstruction. Cataracts exhibit either the singular perpendicular descent of a mass of water, or a series of descents, according as the change from a higher to a lower level is effected at once, or by several precipices. They depend for their sublimity upon the height of the Falls, but mainly upon the magnitude of the volume of water.

The Falls of Niagara, one of the grandest natural spectacles on the globe, occur in the river Niagara, which connects Lake Erie with Lake Ontario, and divides Upper Canada from the State of New York. The river, about three-quarters of a mile wide, first descends over a rugged limestone bed about 50 feet in less than a mile, forming rapids, and is then thrown down perpendicularly, Goat Island, near the centre of the stream, dividing the Falls. The largest of these, on the Canadian side, called the Horse-shoe Fall, from its shape, is 1800 feet broad, more than the third of a mile, and 153 feet in height. The other, on the American side, is 600 feet in breadth, and 164 feet in height. A cloud of mist points out the locality of the cataract at a distance, and under favourable circumstances its roar may be heard for 40 miles. Below the Falls, the river flows in a deep narrow chasm, between almost perpendicular banks, from 250 to 300 feet high, emerging at Queenstown, at the distance of seven miles, into an open and flat country, nearly on a level with Lake Ontario. It has long been supposed, that the Falls were first situated at the present opening of the gorge, to which the Niagara flowed in a shallow channel from Lake Erie, and that the river has been slowly eating its way backwards through the rocks for a distance of seven miles. It is known that the Falls have retrograded during the period of modern observation, at a slow rate, the consequence of disintegration. Many rivers have higher falls, but the volume of water is far less.

This erosive action of running water is strikingly exhibited by several rivers which penetrate through rocks and beds of compact strata. The formation of the magnificent rock-bridge which overhangs the course of the Cedar Creek, one of the natural

Natural Bridge, Virginia.

wonders of Virginia, is due in part to the solvent and abrading power of the stream. It is 213 feet above the river, 60 feet wide, 90 long, and the thickness of the mass at the summit of the arch is 40 feet.

PRINCIPAL WATERFALLS AND RAPIDS.

EUROPE.

Staubach, near Lauterbrunnen in Switzerland, a perpendicular descent of 800 feet.

Reichenbach, canton of Berne, a series of six falls, one of which is 250 feet, the whole forming a descent of 1000 or 1200 feet.

Rheinfall, canton of Schaffhausen, where, after a succession of rapids, the Rhine bursts in three distinct branches over a precipice upwards of 80 feet high.

Saut de Doubs, canton of Neuchatel, a fall of the Doubs of 80 feet.

Ache, a small river of Bavaria, descends, in five great falls, 2000 feet. The current of air produced by the descent is so violent that it can hardly be withstood.

Terni, Italy, a fall of the Velino of 300 feet, usually regarded as the finest European cataract.

Trollhatten, Sweden, on the river Gotha, which rushes down a deep gorge, a height of 190 feet.

Clyde, near Lanark, in Scotland, a series of falls extending over four miles, amounting to 230 feet.

Grey Mare's Tail, in the county of Dumfries, a discharge of the waters of Loch Skene, which fall 350 feet.

Upper and Lower Falls of Foyers, near Loch Ness, the Upper consisting of three descents, amounting to about 300 feet: the Lower a single leap of 212 feet.

Rapids of the Danube, three between Drencova in Hungary and Scala Kladova in Servia, the principal and last or lowest of which is the celebrated Iron Gate, formed by a ledge of rocks running across the bed of the river, over which it rushes with immense force, producing below dangerous eddies and whirlpools.

Rapids of the Dnieper, extend for 150 miles from Krementchchug to Alexandrofsky, where there is no navigation.

Rapids of the Shannon, above Limerick, obstruct its navigation completely, which is carried on by means of lateral cuts. The river issuing from Lough Allen has a descent of 161 feet; but of this fall 97 feet lie between Killaloe and Limerick, a distance of 19½ miles.

ASIA.

Falls in Bundelcund, a part of Central India:—1. at Bilohi, of 398 feet; 2. at Bouti, of 400 feet; 3. at Keuti, 272 feet; 4. at Chacai, 362 feet; and 5. on the Tonse river, 200 feet.

Falls of Girsupah, near a town of that name in the Western Ghauts, where a considerable stream has a tremendous fall of 872 feet.

Falls of the Cauvery, the principal river of Southern India, two cataracts, not far from Seringapatam, of extraordinary grandeur, 350 and 460 feet high.

Rapids of the Kizilozan, in Persia, formed by the famous pass of Rûdbar, a deep gorge 30 miles long, through which the river rushes with incredible velocity.

AFRICA.

The Tecazze, an affluent of the Nile from the high mountains of Lasta, receives its name, signifying "the terrible," from its numerous cataracts, from 100 to 150 feet high.

The cataracts of the Nile are more properly rapids, nine or ten in number, consisting of successive sloping descents, with perpendicular falls of water, seldom more than a foot high.

King George's Cataract, on the Orange River in South Africa, discovered by Mr. Thomson in 1824, a fall of 400 feet.

AMERICA.

The Falls of Niagara, already described, have been estimated to roll down 18,524,000 cubic feet of water per minute.

Potomac, in Maryland; the Little Falls are rapids; the Great Falls descend 76 feet in about a mile and a half, and have in one place a perpendicular plunge of 15 feet.

Passaic, a river in New Jersey, falls 70 feet into a chasm.

Montmorenci, a river in Lower Canada, near Quebec, descends 240 feet in an unbroken sheet.

Falls of St. Anthony, on the Mississippi proper, 700 miles from its source, a descent of 17 feet.

Falls of the Missouri, 500 miles from its source, a succession of rapids and cataracts, 26, 47, and 87 feet in perpendicular height; the great river descending 360 feet in 17 miles, forming a scene only inferior to Niagara.

Rapids of the St. Lawrence, above Montreal,—the Coteau du Lac, the Cedars, the Split Rock, and the Cascades, extending about 9 miles.

Cataract of Tequendama, in the environs of Santa Fe de Bogota, a magnificent fall of the river by which the plateau is drained, of 574 feet.

X. Rivers depend for their magnitude upon various elements, the length of their course, the extent of their basins, the rain-producing character of the climate, and connection with mountains covered with eternal snow. The Mississippi, following the Missouri branch, which ought to be the name of the united streams, has the longest course of any river on the globe; but the Amazon stands at the head of rivers, draining by far the largest area of country, and rolling the greatest volume of water to the ocean. The length of the principal rivers, with the area of their basins, is given on the Hydrographical Map. The following Table exhibits a proportionate view of these elements, to be considered as approximations merely:

	Proportional Length.	Proportional size of Basin.	Proportional quantity of water discharged per annum.
Thames	1	1	1
Rhine	4½	12½	13
Loire	4	2½	10
Po	2½	5	6
Elbe	4½	9	8
Vistula	4½	13½	12
Danube	9½	56	65
Dnieper	7½	36	36
Don	7½	37	38
Volga	14	94	80
Euphrates	9½	42	60
Indus	11½	72½	133
Ganges	10	76	148
Yang-tse-Kiang	21½	138	258
Amour	16	164	166
Lena	13½	174	125
Obi	15	236	179
Nile	18½	90	250
St. Lawrence	22½	109	112
Mississippi—Missouri	23	249	338
La Plata	13½	225	490
Amazon	22¾	395	1280

XI. Some peculiarities of rivers remain to be noticed. The effect of the junction of two great streams is not always an expansion of the surface, but sometimes a contraction, the depth of the channel being increased, and the velocity of the current. The Mississippi is upwards of a mile, and the Missouri half-a-mile wide at their confluence, but from thence to the mouth of the Ohio the medium width of the united waters is only three-quarters of a mile. The Nile is remarkable for not receiving a single brook between its junction with the Tecazze and the Mediterranean, a distance of 1500 miles; a fact without parallel anywhere else. Some rivers temporarily disappear in swamps and underground channels, having in the latter case in many instances scooped their way through obstructing rocks. The Rhone, soon after coming within the French frontier, has a subterranean course for about a quarter of a mile; the Guadiana is lost for about 7 leagues in sandy and marshy grounds, emerging at the Ojos (eyes) de Guadiana. Powerful streams meeting with strong oceanic currents and tides frequently occasion a violent disturbance of the waters, as the effect of the collision and strife for the mastery. When the tide ebbs in the Amazon, the river pours forth its liberated flood with increased force and velocity, and meeting nearly at right-angles with the sea-current from Cape St. Roque, an enormous wave is created, the *prororoca* of the Indians, from the agitations of which fishermen and navigators fly in dismay. A similar phenomenon occurs at the embouchere of the Garonne, and forms the terrific *Bore* of the Hooghly, off the mouth of the Ganges.

Valley of Chamouni after a Flood.

CHAPTER V.

LAKES.

THE inland waters which pass under the denomination of lakes are most numerous, as well as upon the largest scale, in the higher latitudes, and have a marked northerly distribution in particular localities, as those of the Alps and Pyrenees are chiefly on the Swiss and French side of the mountains. Some expanses, lifeless and in general small, occupy the highest mountain passes; larger sheets are found on lower table-lands; but the most extensive are on the great lowlands of the globe. The elevation of some principal lakes is shown on the Hydrographical Map. A space of nearly 17,000 feet extends between the highest, the Sir-i-Kol, and the lowest, the Dead Sea. Four great systems are traceable: two in the old world, and two in the new,—the latter the grandest of all.

1. A system of lakes commencing in Great Britain extends through Norway and Sweden, along the south coast of the Baltic, through Finland, North Russia, North Siberia, to Behring's Strait. The areas of the most important are, Saimas, in Finland, 1602 square miles; Wener, in Sweden, 2136; Onega, 3280; and Ladoga, 6330, both in North Russia.

2. A second system extends principally north of the mountain spine of the old world, and includes the lakes of the Pyrenees, Alps, Apennines, Bavaria and Austrian Empire, Western and Central Asia. The Caspian Sea, the largest lake on the globe, belongs to this band, and has an area of 160,000 square miles, nearly equal to the kingdom of Spain; the second in point of extent, Lake Aral, has an area computed at 21,000; the third, the crescent-shaped Lake Baikal, surrounded by lofty granite mountains, is 1793 feet above the sea, about 1200 miles in circumference, with an area estimated at 12,800 square miles.

3. A third system comprises the great Canadian masses of fresh water, with their dependencies, which are continuous, connected by rivers: Lake Superior, area 43,000 square miles, nearly equal to the extent of England; Huron, 25,000; Michigan, 25,000; Erie, 11,000; and Ontario, 10,000. The different level of these lakes marks the descent of the country, and the inclination of the uniting rivers. The surface of Lake Superior is 627 feet above the level of the sea; Lakes Huron and Michigan, 595 feet; Lake Erie, 565 feet; and Lake Ontario, 231 feet.

4. A fourth system, north-west of the former, extends from the Lake of the Woods to the icy shores of the Arctic Ocean, including Lake Winnipeg, area 9000 square miles; Athabasca, 3000; Great Slave Lake, 12,000; and Great Bear Lake, 8000.

Independent of these systems, there are a vast number of lakes in Northern, Central, and Southern America; some of very considerable extent occur in Africa; others in China, as the celebrated *Mer des Etoiles*, (the *Sea of Stars*,)—the mysterious sources of the Hoang-ho.

II. The water of lakes is derived either from rivers or subaqueous springs. They are for the most part affected by seasonal changes, in some instances spreading out in extensive inundations, followed by a corresponding reduction of surface. The lake of Cirknitz, alternates from being full to absolute dryness, from which a

HYDROGRAPHY:—DEPTH OF THE PRINCIPAL LAKES.

connection, through crevices in its bed, may be inferred with a subterranean body of water, whose increase and diminution from rain and drought causes its intermissions. The greatest depths of the following lakes are:

	Feet.
Lough Neagh, Ireland, largest lake in the United Kingdom	102
Killarney, Lower Lake, ditto	252
Lomond, Scotland, average depth 120 feet	720
Ness, ditto	810
Constance, Switzerland, near the south-east extremity	2334
Geneva, ditto, medium depth, 560 feet; greatest depth, at Meillerie	1000
Neuchatel, ditto, level varies greatly	426
Lucerne, ditto	600
Zurich, ditto	600
Maggiore, Italy, 800 metres	2625
Como, ditto, 588 metres	1698
Iseo, ditto, between Bergamo and Brescia	984
Garda, ditto, Lombardy	951
Nemi, ditto, south of Albano	2700
Wener, Sweden, average depth 120 feet	288
Wetter, ditto	440
Hielmar, ditto	66
Caspian Sea contains extensive shallows, but at one place near the middle no bottom has been found at the depth of	2800
Superior, depth varies from 500 to 900 feet, and amounts in some places to	1200
Huron	1800
Michigan	900
Erie, depth seldom exceeds 100 feet, though reaching in a few places to	270
Ontario, general depth varies from 15 to 500 feet, but in the middle it exceeds	1800
Titicaca	720

It affords a striking instance of deep indentation in the solid matter of the globe, that while the surface of the Caspian is 83·4 feet below that of the Black Sea, its bed at one place descends upwards of 2800 feet below that level, or has a total depression of more than 2883 feet below the level of the sea. It appears also that while the surface of Lake Superior is 627 feet above that of the Atlantic, its bed descends 573 feet below it; while Lake Ontario, with a surface elevation of 231 feet above that of the sea, descends in its bed upwards of 1569 feet below its level.

III. A fourfold classification may be made of lakes, founded upon their physical differences. 1. Some have no apparent affluents or outlets. They commonly occupy hollows, extinct volcanic craters, and depend upon subaqueous springs to supply the waste occasioned by evaporation. 2. Others have outlets, but no apparent affluents, deriving their supplies from subterranean sources. 3. A third class have both affluents and outlets, the common arrangement. They are either formed by a number of streams flowing into a central basin, the superabundant waters escaping by a principal outlet, or they occur in the channel of a river, the waters of which enter and escape at opposite extremities. 4. A fourth class receive affluents, but have no outlets. Lakes of this class are rare, but the great inland salt waters of the Caspian, Lake Aral, and the Dead Sea, belong to it, supposed by some; in common with similar saline waters, to be the remains of the universal ocean which once covered the earth.

Though the Caspian has no outlet, while receiving the majestic volume of the Volga through its seventy mouths, the largest river of Europe, with the Ural and other great streams, an immense evaporation not only keeps its level in check, but appears to exceed the supply. Its waters are however thought to be subject to anomalous variations, increasing and decreasing in volume through periods of about thirty years. Lake Aral is diminishing rapidly. The Kirghisians pointed Baron Meyerdoff to inland places in their memory covered with its waters. Most of the lakes of western Asia appear to be decreasing in magnitude, losing more water by evaporation than what is supplied by tributaries, and at the same time becoming more salt.

IV. Some lakes exhibit the phenomena of floating islands, anomalous undulations, and other striking peculiarities.

1. Floating islands have been formed by the gradual accumulation of vegetable matter, of reeds, marsh plants, and trees from the undermined banks, matted together, with accretions of sand and gravel deposited by the water. There are several examples, clothed with living vegetation, even with forest trees, and cattle have been pastured on them. Similar formations are common in the North American rivers from accumulations of drift-wood. The "Great Red River Raft" obstructed completely the navigation of that noble stream for no less a space than 165 miles, till the impediment was removed at a great expense by the United States government in 1838. The dimensions of a raft of the same kind in the Mississippi are given at 10 miles long, 220 yards broad, and 8 feet thick, supposed to have been formed in about 40 years, presenting all the appearances of solid land, having green bushes and beautiful flowers.

2. The Lake of Zurich is distinguished annually by the appearance of a very minute vegetation upon its surface, exhibiting what is called the flowering of the waters.

3. The *Seiches* of the Lake of Geneva, observed also in other places, consists of a sudden rise in the form of a tidal wave, sometimes amounting to five or six feet in a few hours, apparently due to a local and transient change of atmospheric pressure. The *Vaudaise* of the same lake, an agitation of the water, sometimes violent, appears to be due to the escape of subaqueous currents of air. A lake near Boleslau, in Bohemia, of unknown depth, in winter, is so disturbed by subaqueous winds, that masses of ice are said to be actually thrown up to some height from its surface. The beautifully clear Lake Wetter, in Sweden, is subject to agitation from the same cause.

4. The attractive power of the mud at the bottom of some of the North American lakes has been noticed by Sir Alexander Mackenzie, Captain Back, and others. It is only observed in shallows, and is sometimes so great that boats can scarcely be urged on at all.

5. One of the bays of Lake Huron, seems to be the focus of peculiar electrical phenomena, for whenever traversed, peals of thunder are said to be heard.

6. Lake Baikal—the holy sea of the Tunguses and Yakutes, the largest body of fresh water in the old world, and the largest of all elevated lakes; exhibits the most striking peculiarities. In the most perfect calm, its surface is seldom without an undulation, which increases previous to a wind arising, the undulation proceeding from the quarter of the wind. Frequently shocks from internal commotions are experienced on board of vessels, so violent, as to make it difficult to stand in them. The lake lies in the focus of earthquakes, or near it, which are very common, and to the operation of that force its phenomena are no doubt due.

Loch Katrine.

CHAPTER VI.

THE OCEAN.

THE waters which continuously environ the continental and island masses form a single ocean, but are conveniently divided into several great sections, an arrangement facilitated by the irregular distribution of the solid and fluid portions of the surface. Thus we have the Arctic, Atlantic, Indian, Pacific, and Antarctic oceanic basins.

I. The Arctic basin, surrounding the North Pole, is bounded by the northern shores of America, Europe, and Asia, and in the spaces between the two continents, the astronomical line of the arctic circle is usually considered as its limit.

Principal Branches,—Baffin's Bay, the White Sea, Sea of Kara, Gulf of Obi, Behring's Strait.

2. The Atlantic basin lies between America on the west, Europe and Africa on the east, and the polar circles on the north and south. The equator divides it into the North and South Atlantic.

Principal Branches,—The Baltic, with its gulfs, the German Ocean, the Mediterranean and Black Seas, Gulf of Mexico, the Caribbean Sea, Gulf of Guinea.

3. The Indian basin has for its boundaries, Africa on the west, Persia and Hindostan on the north, the Sunda Isles and New Holland on the east, and the Antarctic Ocean on the south.

Principal Branches.—The Red Sea, the Persian Gulf, the Bay of Bengal.

4. The Pacific basin is enclosed between America on the east, Asia, the Sunda Isles, and New Holland on the west, and the Antarctic Ocean on the south. The equator divides it into the North and South Pacific.

Principal Branches.—Sea of China, Yellow Sea, Sea of Japan, Sea of Okhotsk, Gulf of California, Gulf of Panama.

5. The Antarctic Ocean is confined between the south pole and the Antarctic circle.

II. The Arctic Ocean is closed to navigation in its higher latitudes by eternal frosts. The summer and winter limits of the frozen zone are shown on the Meteorological map, which of course descend more southerly in the latter than in the former season; but as the Arctic winters vary in severity, like those of temperate climates, though not so extensively, the area of the ice formed, varies correspondingly. Hence some navigators have found an open ocean, where to others it has presented an impassable icy barrier at the same period in a different year, and have been unable to penetrate to the high latitudes reached by the former. In summer, when the whalers pursue their perilous occupation at a high latitude in the northern seas, the waters, though open, are by no means clear, but exhibit immense icy masses floating to and fro, fraught with peril to the voyager, which are drifted by the winds and currents far from the sites of their origin, some perishing by collision, and others reaching the heart of the Atlantic, where they are dissolved in its warmer waters.

These floating masses are of two kinds, sheet ice and bergs, which have quite an independent origin.

1. Sheet ice resembles that of lakes and rivers, presenting a generally level surface, but here and there diversified by projections, called *hummocks*, the ice having been thrown up by lateral pressure, upon two masses coming into collision. Sheets of ice, the whole extent of which cannot be seen from the masthead of a vessel, are called *ice-fields*, and have sometimes an area of more than 100 square miles, rising from 2 to 8 feet out of the water. Smaller sheets are called *floes*. Fields and floes when much broken up, the fragments crowding together, form what is termed a *pack*, which when much elongated, is called a *stream*. When the parts of a pack are loose and open, so that a vessel may sail between them, it is called *drift-ice*; and *brash-ice* when the fragments have been much ground down by abrasion. The *ice-blink* is a stratum of lucid whiteness on the verge of the horizon, indicating its presence in the direction of the appearance. These shoals of saline ice are the work of the arctic winter's cold, which freezes the superficial waters of the ocean to an extent and depth proportional to its intensity and continuance. Upon the return of a milder temperature the ice formed is gradually broken up, the ocean is unbound, enormous fields of its solid covering are set afloat, soon to be reduced and dissipated by thawing, by concussion with each other, and by the ordinary swell of the sea, which acts with tremendous power upon a large tract. But in some cold seasons the floating ice is overtaken before dissolution by the frost of an early winter, and preserved to the following summer.

2. Icebergs, altogether different in shape from ice-fields, towering like cliffs to a considerable height, are quite distinct in origin, being fresh-water formations from the arctic lands, identical with the glaciers of the Alps. They have their principal birthplace on the coasts of Spitzbergen and the eastern shores of Greenland. The latter site presents to the play of the waves a breastwork of ice upwards of 600 miles in length, formed by the congelation of the fresh water produced in summer by the melting of the snow. The annually renewed congealed masses, projecting into the sea, yield to its undermining and wrenching power, by which immense blocks are broken off, constituting icebergs. The process has often been witnessed by the Danish residents, by whom it is familiarly termed the *calving* of the glacier. Mr. Darwin observed it likewise along the coast of Terra del Fuego. Icebergs are found of various dimensions, from a few yards to miles in circumference, rising hundreds of feet out of the water, having the appearance of glittering chalk cliffs, their fractures showing an emerald green hue; azure blue pools lying on their surface, or falling in cascades into the sea.

Data are as yet much wanting respecting the extent of the permanent polar ice. Only the general limit of the winter ice is pretty well ascertained in the northern hemisphere. It occupies the northern coasts of America, encloses Hudson's Bay, Baffin's Bay, and part of Davis's Strait, extends along the shores of Labrador, Newfoundland and Greenland, to Spitzbergen, but excludes Iceland and the Small Bear Island, south of Spitzbergen. The latter has been accessible to vessels in the severest winters. It embraces all the northern coasts of Asia, but in the eastern portion it has been observed to terminate north of the islands of Kotelnoi and New Siberia, and from thence at a less distance from the continent further east. This part of the Arctic Ocean has been called in consequence Polynja, or "open water." In summer the compact ice breaks up as far as the northern shores of Nova Zembla, Spitzbergen, and Baffin's Bay.

Icebergs.

HYDROGRAPHY:—THE FIVE GREAT OCEANIC BASINS.

III. The Atlantic Ocean rolls in the deep longitudinal valley between the eastern shores of America and the western coasts of Europe and Africa, which exhibit corresponding projecting and retiring angles, a disposition to interlock. The valley, comparatively narrow towards the equator, expands from thence north and south. This portion of the great deep is the best known of any, as the highway of the world's commerce, perpetually traversed by hosts of merchant vessels, in which millions of property and thousands of lives are embarked. Its tropical districts exhibit several remarkable phenomena—the phosphorescence of the sea—the flying-fish chased by the dolphin—successive regions of steady breezes and calms, the latter interrupted by short and sudden squalls, and enormous deluges of rain towards the equator generally descending in a perfectly still state of the atmosphere. The region of steady breezes, where the waves are low and the swell is gentle, the Spaniards called *il golfo de las damas*, from the easy navigation, supposing that even women might venture to conduct the navigation from the Canaries to America. The South Atlantic has no peculiarities which require notice, but several belong to the northern portion.

1. The North Atlantic is remarkable for the number and extent of its indentations of the continents, some of which form mediterranean or close seas, as the sea of that name, which alone affords a navigation of 3000 geographical miles, and the Baltic.

2. A very large portion of the surface of the North Atlantic is occupied by sea-weed, (*fucus natans,*) closely matted together, forming the "Grassy Sea" of the English, the Kroos Zee of the Dutch—"sea of duck-weed," and the Mar de Sargasso of the Portuguese and Spanish—"the sea of lentils." A well-defined region of the weed extends along the meridian of 40° W. and between the latitudes 20° and 45° N., bearing the name of the "Fucus Bank of Corvo and Flores," from the two most western islands of the Azores, which are situated not far from it. It occurs also from thence in varying quantities to the Bahamas, the area occupied amounting to 1,000,000 geographical square miles and upwards, almost six times the extent of Germany. Much of this sea-weed may be brought down by the gulf stream from the Gulf of Mexico; but the quantity is so great that Humboldt reasonably infers the existence of an immense sand-bank in the Atlantic on which it grows.

3. Drift-ice annually makes its appearance in the North Atlantic, much nearer to America than to Europe, borne by a current from the Arctic seas. It descends more southerly before being dissolved, as might be expected, in the spring months, March and April, than in the summer months, May and June. Icebergs travel south in the Atlantic to $40\frac{3}{4}°$ of latitude, but are confined to the space between 42° and 50° of west longitude; ice-fields of any extent seldom pass southward of 45° of latitude. Deviations from these limits occur, but they are very rare. In 1817, when many thousand square miles of ice, which from time immemorial had been permanent on the north of Iceland, suddenly broke up from some unknown cause, drifts occurred in 32° of longitude, but about 800 miles west of Ireland. Again, in 1841 the "*Great Western*" steamer encountered an extensive ice-field between 42° and 43° of latitude, and proceeded along its southern edge from east to west for more than a hundred miles. This was the year in which the ill-fated steamer the "*President*" was lost, most likely by being surrounded and crushed by the floating ice which came out in peculiar force at that period from the northern regions.

IV. The Indian Ocean has no distinct character independent of phenomena which belong to the department of meteorology, its hurricanes and monsoons. The Pacific, properly styled the Great Ocean, is chiefly remarkable for its vastness, and the number of its islands. On the American side, it corresponds to the South Atlantic in rarely running into the land: on the Asiatic side, it corresponds to the North Atlantic, in largely indenting the coasts. The seas of China, Japan, and Okhotsk, enclosed with islands, are the analogues of the Caribbean Sea and Mexican Gulf, shut in by the West Indian groups. The Antarctic Ocean presents similar features to the Arctic, but is more completely an icy sea, and the drift ice appears to travel farther from the south, than from the corresponding pole. Even near the Cape of Good Hope and the mouth of the Plata River, icebergs have been encountered, at about latitude 36°.

Packed ice occurs in immense quantities in the Antarctic Ocean, but great differences subsist respecting its *locale* in different seasons. The discovery ships under Sir James Ross passed through a belt upwards of 800 miles broad, where Cook, under the same meridian and in the same latitude, had no occasion to enter the pack at all. The southern icebergs have not the diversity of form of the northern, being commonly tabular masses. Ross met with the same berg on two succeeding years, 150 feet high and 4 miles in diameter, which appeared from its change of place to have drifted at the average rate of about a mile per day. He reached the latitude of 78° 10′, the highest ever attained in the southern hemisphere; Parry in the northern, by travelling over the ice, penetrated to 82° 40′.

V. Some variations of level are observed between different sections of the universal ocean. This is the effect of local winds and currents, and chiefly occurs in landlocked seas.

The surface of the Red Sea at the Isthmus of Suez is from 24 to 36 feet above that of the Mediterranean. This is caused by the peculiar form of the canal connecting the Red Sea with the Indian Ocean, the Straits of Babelmandel, through which the oceanic waters find readier access than outlet.

The effect of the equatorial current which sweeps across the Atlantic from the Gulf of Guinea to the Gulf of Mexico, where its farther progress westward is arrested, is to pile up the waters in the latter to a considerable height above the level of the ocean near the Cape de Verde Islands.

There is no great difference, as formerly supposed, between the level of the Pacific at the Isthmus of Panama, and that of the Atlantic on the opposite side.

VI. The bed of the oceanic waters exhibits similar inequalities to those which mark the surface of the dry land—abrupt eminences, gentle slopes, and deep depressions; and hence the various depths of the fluid, now beyond the reach of the sounding-line, or a thin stratum scarcely concealing the sand-bank from the eye of the navigator. Off a low, level, and sandy shore, the sea is in general shallow for a considerable distance, and very deep close to a bold towering coast. But near to islands of coralline formation, which are so little elevated as not to be visible at any great distance, the Pacific Ocean frequently shows profound depths. Within a mile and a half of Keeling Island, Captain Fitzroy found no bottom with a line of 7200 feet, plainly proving it to be the crest of a lofty submarine mountain, with sides steeper than those of the most abrupt volcanic cones.

The south part of the German Ocean is very shallow, sandbanks encumbering its bed; but towards the north the depth increases to from 300 to 540 feet between Kinnaird's Head, Scotland, and the Naze of Norway.

The Mediterranean, on the contrary, has generally a great depth, being 1800 feet deep between Italy and Greece, 2700 in the Gulf of Nauplia, 3000 between Sardinia and Sicily, 4800 north-west of Sardinia, and 5880 between Spain and Africa.

The Atlantic shows a depth of 600 feet on the north of Ireland, and 1662 feet on the south-west. It does not perhaps exceed 3000 feet anywhere in the tract between Europe and the United States. In the channel of Yucatan the soundings reach to 6000 feet. The greatest depths are in the South Atlantic. About midway between the Cape of Good Hope and Rio Janeiro, Sir James Ross found the depth 14,550 feet; a depression of the bed of the ocean very little short of the elevation of Mont Blanc above it. About 450 miles west of the Cape of Good Hope he found the depth 16,020 feet; but on June 3, 1843, the water being calm and smooth, a line of 27,600 feet did not reach the bottom. This is the greatest depth of the ocean that has yet been satisfactorily ascertained. The spot was in 15° 3′ S. lat. and 23° 14′ W. lon., about 486 miles from the small island of Trinidad, and 1180 from Cape Frio, the nearest point of South America.

VII. The pressure exerted by the ocean, increasing with the depth, must be enormous in its more profound abysses. Even at the depth of 120 feet, the same amount of sea-water will be reduced in bulk by compression from 20 to 19 solid inches. In the Arctic Seas, where the specific gravity of oceanic water is at its minimum, its pressure on a square inch of surface is estimated to be 2809lbs. at the depth of 7600 feet. A sensible proof of the pressure at a great depth was afforded to Captain Scoresby. A piece of wood that got entangled, and was dragged down by a whale, was found when drawn up so saturated with water forced into its pores, that it sank like a stone for a year afterwards instead of floating.

Alum Bay, Isle of Wight.

CHAPTER VII.

OCEANIC MOVEMENTS.

THE ocean is subject to the three general movements of waves, tides, and currents, the causes of which are independent. The wave movement is of an inconstant and transitory character, occasioned by winds; that of the tides is regular and periodical, the result of the attractive influence of the moon, modified by that of the sun; while the currents are the effect of various circumstances, and permanently flowing, resemble great rivers in the sea.

II. Waves arise from the action of the atmosphere, the lower stratum of which is in contact with the surface of the ocean, and when agitated by winds, disturbs the equilibrium of the water, in proportion to the intensity and duration of the force exerted. The progressive motion of the undulations produced appears like an onward flow of the water, but a bird resting on the sea, or a boat adrift upon its surface, is not carried forward by the waves. There is merely a rise and fall with them, except in the case of a strong continuous wind, which occasions a superficial current. At a comparatively small depth, the ocean is tranquil, when furious tempests are agitating its surface.

1. By experiments in 1836, it was found, that in water 12 feet deep, waves 9 inches high and 4 or 5 feet long, did not sensibly affect the water at the bottom. The effect of the strongest gales does not probably extend beyond the depth of 200 feet.

2. The common saying of the waves running mountains high is a popular exaggeration. The highest rise noticed in the Mediterranean is only 16 feet, and 20 feet off Australia. The French ship Venus, in a recent circumnavigation of the globe, met with no wave higher than 23 feet. In the Bay of Biscay, during a strong south-westerly breeze, the highest waves measured by Sir James Ross scarcely exceeded 36 feet from the base to the summit; and in the south Atlantic, the result of several experiments gave only an entire height of 22 feet, and a velocity for the undulations of 89 miles per hour, the interval between each wave amounting to 1910 feet. Off the Cape of Good Hope, notoriously the Cape of Storms, according to its former name, 40 feet is considered the extreme height of waves, or 20 feet above and below the general level of the ocean.

3. Waves formed by a wind blowing from the shore, increase in height with the distance from the land, but preserve the same height while the impulse is the same.

4. A breeze blowing perfectly parallel to the level of the water produces waves, but the surface continues smooth. The slightest inclination in the wind causes ripples. Local and transitory deviations from the parallel direction occasion the streaks of ripples that are often seen running along the smooth general surface, the "catspaws" of mariners.

5. Oceanic waves are long rolling billows; those of close seas are abrupt and short.

6. Long after the storm-winds have subsided, and the surface of the ocean has become smooth, it is observed to heave with mighty undulations, which are propagated far beyond the area visited by the gale, the oscillations becoming more feeble with the distance from the focus of disturbance. This is called the "swell." It is not uncommon for a swell advancing in one direction to meet another coming from an opposite quarter, and even a third from another point; or after a breeze has produced a series of waves, it may chop about, and form an inverse series; or within a limited space, aërial currents may be blowing at the same time from various points of the compass; in either of which cases, the aspect of the surface water becomes complex in the extreme.

III. The theory of the tides has been explained as far as it depends upon astronomical causes, the attraction of the moon being the prime agent, strengthened or weakened by that of the sun, according as the relative position of the two bodies with regard to our planet enable them to act in concert or in opposition, their influence being modified by a varying distance from the earth. (Astronomy, page 24.) The south polar ocean is the only deep, unobstructed, and sufficiently capacious sea-basin extending east and west for the production of a wave of high water. The innumerable islands, coral reefs, and submarine table lands of the Pacific are impediments to tidal phenomena, while the Atlantic is disqualified for originating a great wave or tide owing to its form and direction, that of a narrow meridional canal. Accordingly, it has been ascertained, that the seas to the south of New Holland form the grand centre from which tidal action radiates. A high water ridge being raised, and receiving an impulse in the direction of the acting luminaries,—that is westward, the apparent lunar and solar path, but trending north towards the tropics, the region of the direct line of their attraction,—it expends its force in displacing a contiguous mass of fluid, similarly raising it, and in like manner the undulation is propagated with immense velocity from the scene of its origin. It travels at the rate of nearly 1000 miles an hour in the deep and open southern ocean, but with a much less velocity in shallows and near the land, owing to obstruction from the shores and bed of the sea. The propagation of a tide-wave is not a transference of water, but the motion of an undulation. There is no perceptible advance in the profound open sea, only an alternate rise and fall of the surface; but a flow of water takes place over shoals and near land.

The general history of a tide-wave may be briefly sketched, the reader bearing in mind, that in rather more than 12 hours after it has started on its route, another has set out on the same course.

Suppose that at 11 A.M. a tide-wave has brought high water to the coast of Van Diemen's Land. In thirteen hours, or at 12 midnight, it will strike the south point of Hindostan, the east coast of Madagascar, and be off the Cape of Good Hope, carrying high water to those localities. Arrived at the entrance to the Atlantic, it follows the direction of the ocean, north by west, successively bringing high water to the different ports on its eastern and western shores, but travelling with much greater velocity through its central parts than along the coasts, so that the cotidal line becomes extremely elliptical. Thus, in eleven hours from the Cape, or at 11 A.M. of the following day, the twenty-fourth hour of its life, the central area of the oscillation will have reached Newfoundland, its skirts being at the Bahamas on one side, and Cape Blanco in Africa on the other. Turning north-east, the direction of the ocean, in four hours afterwards, or at 3 P.M., the twenty-eighth hour of its career, the tide-wave has advanced to the British Isles, the ridge extending from Ushant, across the mouth of the English Channel, by the south promontory of Ireland, Cape Clear. Here, interrupted in its progress, it divides into three branches. One branch travels up the Channel, carrying high water to the opposite coasts of England and France. A second branch enters the Irish Sea through St. George's Channel. The third and principal branch proceeds along the shores of Ireland and Scotland, rounds the northern extremity of the latter, advances into the German Ocean, reaches Aberdeen at 11 P.M., and finally meets the tide from the English Channel; being in twelve hours more off the mouth of the Thames, at 11 A.M., the forty-eighth hour of its existence.

Thus, in the contracted and shallow German Ocean, the tide-wave occupies as much time in passing from Aberdeen to the mouth of the Thames, as in proceeding through the central part of the Atlantic from the Cape of Good Hope to Newfoundland.

In the open ocean also, as at St. Helena, the rise never exceeds the height of 3 feet, but in narrow seas and confined channels, the elevation is very great, for the same motion is evidently capable of raising the smallest quantity of water the highest. At St. Malo's, on the north coast of France, the spring tides rise 50 feet; at Chepstow in the Bristol Channel 60 feet, and the same in the Bay of Fundy in Nova Scotia. The rise at the London Docks is about 19 feet.

The shores of the Pacific exhibit tidal action very feebly in comparison with those of the Indian and Atlantic Oceans. Great islands, swarms of islets, and vast submarine constructions, allow only to a limited degree the ingress of the oscillations that are generated in the south polar waters. But very little is known at present respecting the course of the tide-wave in the Pacific. Combining a number of observations, Mr. Whewell states, that on the eastern coast the tide comes from the west, arriving first at the coast near Acapulco, and later and later both to the north and south of this point. It passes to the eastward round Cape Horn, as observed by Captain King, and to the northward along the coast of North America, then to the westward along the Aleutian isles, and so to Kamtschatka, as stated by the Russian navigator Admiral Lütke.

Cotidal lines are imaginary lines connecting places to which the same tidal wave brings high water at the same time

The tides in close seas and rivers are variously modified by the action of particular winds. The following information respecting the influence of the wind upon the tides in the Thames is given by Sir James Hall:—"During strong north-westerly gales, the tide marks high water earlier than otherwise, and does not give so much water, whilst the ebb-tide runs out later, and marks lower; but upon the gales abating, and the weather moderating, the tides put in, and rise much higher, whilst they also run longer before high water is marked, and with more velocity of current, nor do they run out so long or so low. The reason assigned for all this is, that the strong north-west winds drive the sea along the Dutch coast, through the straits of Dover, and consequently away from the mouth of the Thames; so that the tides, during north-west winds, are always much higher (producing frequently ruinous flooding) on the Dutch than upon the English coast. A south-westerly gale has a contrary effect generally, and an easterly one gives some water; but the tides, in all these cases, always improve the moment the weather moderates."

The variations of pressure in the atmosphere also affect the height of the tides. With a low barometer, indicating a lighter atmospheric column, the tides may be expected to rise higher, and *vice versâ*, other circumstances being equal. M. Daussy has ascertained, that the British Channel rises more than eight inches for a fall of about half an inch in the barometer. Some remarkable oscillations of the sea on the coast of Great Britain, beyond what could be accounted for by ordinary tides, or any wind prevailing at the time, are probably due to sudden and great changes in the pressure of the atmosphere. Thus, on July 5, 1843, the water suddenly rose and sunk down from 2 to 5 feet in perpendicular height, producing effects more or less striking, according to the shelving character of the shore. The phenomenon, several times repeated, was observed along the south coast of Cornwall and Devon, and the east coast of Scotland from Berwickshire to the Shetlands. On that day, a violent storm traversed the island, from the south-west of England, through the midland counties, and the south-east parts of Scotland, going off about the Aberdeenshire coast. During its passage, the barometer was observed to sink suddenly about an inch at Sheffield.

IV. The oceanic currents, permanent but of unequal force, are the effect of

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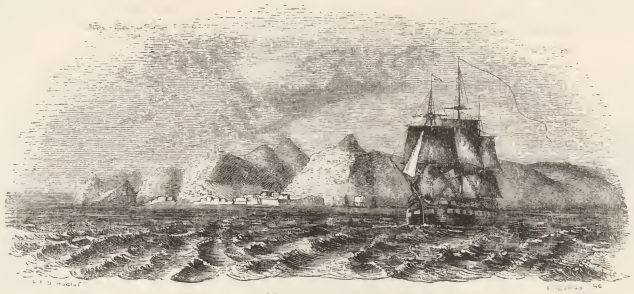
winds, of differences of temperature between different parts of the ocean, of the melting of the polar ice, of variations of atmospheric pressure, and other minor circumstances. Drift currents are due to the action of permanent or prevailing winds upon the surface water, by friction impelling it to leeward, until meeting with some obstacle, such as land, or sand-banks, its progress is arrested, and an accumulation of the water produced. In such circumstances a drift current give rise to a stream current, carrying off the collected waters, to restore the equilibrium of the surface of the ocean.

The velocity of a drift current is in general half a mile an hour: that of a stream current is usually greater, often amounting to five miles an hour.



Island of St. Helena.

V. No ocean is so remarkable for the variety of its currents as the Atlantic, which seem chiefly to arise from the variegated outline of its shores. They are also the most accurately known, its waters having been most subject to scientific navigation. The origin of the main series is at the Cape of Good Hope, and from thence almost a complete circuit of the coasts appears to be made.

I.—CURRENTS OF THE ATLANTIC OCEAN.

1. South Atlantic Current.—This is a discharge of water from the Indian Ocean, by a current round the Cape, which flows northerly along the coast of Africa nearly as far as the equator. It is much colder than the superincumbent air, and is overhung with mist, occasioned by the condensation of the vapour of the atmosphere. Average breadth, according to Sir James Ross, 60 miles: depth 1200 feet: velocity 24 miles per day.

2. Equatorial Current.—So called from its course lying under or near the Line. It is a continuation of the former, commences at the coast of Congo, flows north-west to the equator, which it reaches about the meridian of Greenwich. It then proceeds across the whole ocean, increasing in extent and velocity till off Cape St. Augustin, South America, it divides into two branches. This is the most powerful and extensive of all the Atlantic currents, and by its nature and position interferes the most of any with navigation, forming a wide and complete bar across the narrow part of the ocean between the shores of Guinea and Brazil. Velocity—between the coast of Congo and the island of Annabon, from 14 to 30 miles per day: in its progress to Cape Palmas from 52 to 63 miles: between 10° and 16° W. long. from 44 to 80 miles, the strongest part of the stream: from 16° to the coast of South America the mean velocity is 30 miles per day. Temperature—at least 3° colder than the ocean on each side of it, because its waters come from a colder region.

About the middle of the ocean, in W. long. 23°, the equatorial current sends off a large stream, called from its direction the North-west Branch. It may be traced as far north as lat. 28°, sometimes as far as 30°. This branch favours the return of vessels from the southern hemisphere to Europe. Velocity—about 20 to 24 miles per day up to lat. 10°.

Off Cape St. Augustin, where the equatorial current divides, a branch to the south forms the Brazil current, running at the distance of from 200 to 250 miles from the shore, and extending to the outfall of the Plata River, sometimes traceable much farther. Velocity—off Rio Janeiro, 30 miles per day: near the Plata from 15 to 20 miles.

3. Guyana Current.—The main stream of the equatorial continued along the coast of Guyana to the Caribbean Sea, entering it between the Islands of Trinidad and Martinique. Velocity—varies from 10 to 40 miles per day; it has been found about 90 miles in the strongest part; it decreases towards the coasts.

4. Caribbean Current.—The Guyana current continued through the Caribbean Sea, flowing with a very gentle motion through the channel of Yucatan into the Gulf of Mexico.

5. Current of the Gulf of Mexico.—The slight flow received from the Caribbean Sea divides into two branches: one, turning to the right, passes Cuba to the Strait of Florida: the other, turning to the left, makes a complete tour of the Gulf by Vera Cruz and the mouth of the Mississippi. Both branches flow gently. The temperature of the Gulf of Mexico is at least 7° higher than that of the Atlantic in the same parallel. It amounts in general to 89°, but has been observed 90°, being probably the highest temperature of the ocean over the globe.

6. Gulf Stream.—The branch currents of the Gulf of Mexico unite at the Strait of Florida to form the powerful and celebrated stream which carries off the heated water of the Mexican cauldron, and distributes it at great distances. The stream proceeds along the coast of the United States as far as Cape Hatteras. It then gradually turns eastward, maintains that direction as far as the Azores, where it bends south, and loses itself a little to the south of that group of islands. The length of its course from the Strait of Florida to the Azores is about 3000 geographical miles; but part of the warm waters of the Gulf stream find their way to the shores of Europe as far up as the North Cape, and even to Spitzbergen. Velocity—noted as high as 120 miles per day after passing the narrows of the Strait; 48 to 60 at 1100 miles from its egress; and 30 or more after a course of nearly 3000 miles. Temperature—after issuing from the Gulf exceeds 86°: after running 1100 miles 81°: after 3000 miles 76° to 79°: at the Azores 74°.

7. Arctic Current.—Flows from the Arctic Ocean to the Gulf stream which it joins east of the Great Bank of Newfoundland, the polar ice descending by it into the North Atlantic. Velocity—from 36 to 60 miles per day. Temperature—has been observed 43°, which is 17° below that of the adjacent ocean. It bears the name therefore of the Cold Current. Scoresby counted 500 icebergs setting out upon it at once. The Icelanders receive large quantities of drift-wood by the medium of this current; an important benefaction to them, in the absence of natural forests. It is supposed that the great rivers of Northern Asia bring it down from the Siberian woods to the Ocean, from whence it is transferred to the shores of Iceland.

8. North Atlantic Drift Current.—Comprises that part of the Atlantic east of the Arctic current, and north of the Gulf stream. The direction is easterly towards Europe; the flow very weak: but the two following currents originate from it.

9. North African and Guinea Current.—Commences between lat. 45° and 53°, runs southward between the Cape Verde Islands and the coast of Africa, then turns easterly, and flows close to the equatorial current, but in an opposite direction, into the Bay of Benin. The north part of this current between the Bay of Biscay and Madeira trends easterly, and a portion enters into the Mediterranean through the Straits of Gibraltar. Velocity—12 to 20 miles per day. Temperature—at the Cape Verde Islands 8° lower than that of the surrounding ocean.

10. Rennell's Current.—Begins near Cape Finisterre, runs along the coast of the Bay of Biscay, then shoots across the mouths of the English and Irish Channels, bends round to the west, and thence through all the intermediate points till it falls into itself, performing a complete rotation. It bears the name of the late Major James Rennell, who first accurately traced its course, and is the current which so often endangers vessels near the Scilly Islands. Velocity—on the Spanish coast 24 miles per day: greatest velocity 90 miles, observed on the French coast opposite Brest.

11. Southern Connecting Current.—Arises from the drift current of the south-east trade wind, and flows to the Cape of Good Hope where it divides, a branch joining the North Atlantic current, and another passing into the Indian Ocean.

II.—CURRENTS OF THE INDIAN OCEAN.

1. Bengal Current.—Runs principally along the coast of Coromandel, but depends entirely upon the monsoons for its direction and force. It flows in summer, the time of the south-west monsoon, to the north-east: in the opposite direction in winter, when the north-east monsoon prevails. Velocity—the greatest in winter, often 50 miles per day: east of Ceylon from 30 to 70 miles.

2. Malabar Current.—Flows along the coast of Malabar from Bombay to Cape Comorin: depends upon the monsoons: runs northerly in winter and southerly in summer. Velocity—in winter very slight; in summer from 10 to 20 miles per day, increasing towards Cape Comorin to from 20 to 30 miles.

3. United Bengal and Malabar Current.—The Bengal current, flowing through Palk Strait and round Ceylon, joins the Malabar current, the united waters proceeding westerly towards Africa, depending however upon the north-east monsoon. Velocity—between Ceylon and the Maldiva Islands from 30 to 35 miles per day in winter: towards Africa very slight.

4. Passage Drift Current.—The equatorial current of the Indian Ocean. It originates south-west from Australia, flows first northerly to the Tropic of Capricorn, where it bends west, and sweeps across the whole ocean. Approaching Madagascar, it becomes narrower, and flows on the north of that island towards the African coast, having previously sent off a small branch to the south-west at the Island of Rodriguez. Velocity—near Australia from 20 to 30 miles per day; in the middle of the ocean

from 10 to 20; but north of Madagascar, where it becomes narrow and more powerful, from 45 to 60 miles.

5. Mozambique Current.—The strongest in the Indian Ocean, a continuation of the Passage Drift, which after having passed Madagascar, and being joined by the weak Bengal and Malabar current, turns south, and flows through the Mozambique Canal to the southern extremity of Africa. Velocity—from 20 to 50 miles per day in general; most rapid near the African coast off Cape Corrientes, where it has been observed to run at the rate of nearly 6 miles an hour, or 139 per day. This is perhaps the greatest velocity ever noted of any current.

6. Lagullas or Cape Current.—On the southern extremity of Africa, at the First point of Natal, the Mozambique current is joined by that branch of the Passage Drift which separates from it at Rodriguez; and thus the chief movements of the Indian Ocean here blend, forming a strong stream, part of which reaches the Atlantic, and is called the Lagullas current from the cape and sand-bank of that name. Velocity—greatest at its commencement, from 60 to 110 miles per day: decreases towards the west: mean velocity at the Cape of Good Hope, 33 miles.

7. Counter Current.—The preceding current meets with resistance from the great Lagullas bank, about half-way between the First point of Natal and the Cape of Good Hope, and unable to pass round or entirely over it into the Atlantic, a great portion of the water is returned by a counter current to the Indian Ocean.

III.—CURRENTS OF THE PACIFIC OCEAN.

1. Antarctic Drift Current.—Flows from the south-polar regions in a north-easterly curve towards the coast of South America, where it divides into two branches, nearly opposite the Island of Chiloe.

2. Peruvian or Humboldt's Current.—One of the branches mentioned, first discovered by Humboldt in 1802. It proceeds northwards along the shores of Chili and Peru, as far as Cape Blanco, where it turns north-west, embraces the Galapagos group, and expanding from thence in breadth, is lost in the great equatorial current of the Pacific. Velocity—from Valparaiso to Lima 12 or 18 miles per day: at the Galapagos Islands it has been noted at from 70 to 120 miles.

3. Cape Horn Current.—The second branch from the Antarctic Drift, running south, passing round Cape Horn to the Falkland Isles, and perhaps finally joining the southern connecting current of the Atlantic. Velocity—from 54 to 100 miles per day, in lat. 55° to 58°: near the coast, mean velocity, 24 miles.

4. Equatorial Current.—The principal movement of the waters of the Pacific, from east to west, flowing on both sides of the Line, its limits coinciding with lat. 24° N. and 26° S., making a breadth of 3000 geographical miles. Velocity—the general mean, 30 miles per day.

There are two minor currents within the equatorial, flowing in an opposite direction, from west to east.

Mentor's Counter Drift.—About the Tropic of Capricorn, and the meridian of 80° W., named after the Prussian ship "Mentor," on board of which the first observations were made in 1823.

North Equatorial Counter Current.—Between lat. 5° and 10° N.; long. 115° and 150° W.

5. Mexican Coast Current.—Periodical, dependent on the monsoons, flowing south-east in winter, north-west in summer.

6. Japanese Current.—Formed by the approach of the equatorial current to the coast of Asia. A portion is deflected north by the Island of Formosa, and passes along the east of Niphon, finally losing itself in the ocean. Velocity—off Niphon, from 50 to 120 miles per day.

7. Carolinian Monsoon Current.—Formed by the central portion of the equatorial approaching the Caroline Islands, where it becomes influenced by the monsoons, flowing west in summer, east in winter.

8. Rossel's Drift Current.—Formed by the southern portion of the equatorial, approaching the New Hebrides and New Caledonia, the course changing from west to north-west, towards Torres Strait, named after the discoverer M. Rossel.

9. New South Wales Current.—Runs along the coast from 20° S. to Van Diemen's Land; periodical, depending on the winds; flowing south in summer and north in winter. Velocity—from 20 to 30 miles per day.

10. Current at Behring's Strait.—Flowing from the Pacific to the Arctic through the narrow channel which separates America and Asia. It follows an easterly direction, having passed the Strait, runs along the northern coasts of America, and may not improbably in that way reach the Atlantic. Velocity—greatest on the side of Asia, varying from 35 to 70 miles per day.

See Hydrographical Map of the World, showing the Currents, &c.

VI. The great sea-streams have offsets, in some instances occasional, due to a transitory cause, or there is a change in the set of a current; circumstances which may endanger the most skilful commander, hurry his vessel ashore, when his reckoning gives him a considerable distance from it,—a misfortune which happened in the night to the fine frigate, the "Challenger," in the year 1835, upon the south coast of Chili.

VII. There are strong local currents produced by tidal action, encumbered by narrow channels and projecting coasts, as the "race" of Portland, along the Dorset coast, which flows with considerable velocity, and the "roost" of Sumburgh, at the south promontory of the Shetlands, which runs at the rate of 15 miles an hour. These local currents sometimes meet from opposite quarters, and cause a whirlpool, like the long-celebrated maelstrom, on the coast of Norway, occasioned by the meeting of tidal currents round the islands of Logodon and Maskoe.

VIII. The Oceanic currents have exerted an important influence in the past history of the globe, and are necessary to its occupation by the human race. The productions of the vegetable kingdom have been widely diffused by the transport of seeds in the waters from one region to another. In like manner, animals have been translated involuntarily to a fresh home on floating ice; and canoes of men and women, driven out to sea by the winds, have got entangled in its powerful streams, and been borne to lands before without a human tenant, but thenceforth to be established in them. Materials drifted across the Atlantic to the Azores strengthened Columbus in his design to navigate it, and led to the gates of a new world being opened. The currents carry the warm water of the tropics to the polar regions to moderate the cold, and bear the cold water of the poles to the tropics to moderate the heat. It is the warmth of the Gulf stream, conveyed to the north-west of Europe, that renders the climate so mild, clothing Britain in "ever-green robes," when, in the same latitude, the shores of Labrador are encased in ice. Without waves, tides, and currents, the ocean, charged with an immense amount of decomposing animal and vegetable matter, would become a stagnant fetid pool, give off noxious exhalations, infect the whole atmosphere, and reduce the habitable parts of the earth to the condition of a desert.

Strait of Gibraltar.

CHAPTER VIII.

ACTION OF THE WATERS UPON THE LAND.

I. Mere rain is a powerful agent of disintegration, and in course of time largely alters the contour of the most solid masses subject to its action. The tremendous showers which fall upon the plateau of Abyssinia, originating the floods of the Nile, have given a peculiar shape to its projections, in process of further change. Some are flat, thin, and square, in form of a hearth-stone or slab, scarcely seeming to have base sufficient to resist the winds; others are like pyramids, obelisks, and prisms; and some, the most extraordinary of all, resemble pyramids pitched upon their points, the base being uppermost. The torrents discharged from the clouds have been for ages skeletonising the country, dismantling the harder masses of the softer deposits, wearing away also the granitic rocks, and carrying away the soil of Ethiopia, strewing it along the valley of the Nile, and the shores of the Mediterranean.

Disintegrated Granite.

The effect of rain is universally similar in proportion to its violence. The Devil's Arrows, near Boroughbridge, Yorkshire, three gigantic obelisks or single stones, supposed to be Druidical, are fluted from this cause from top to bottom. In the same county, the mountain limestone floors supporting the noble masses of Ingleborough, Penyghent, and Wharnside, exhibit rain channels, which have often attracted the attention of artists and tourists.

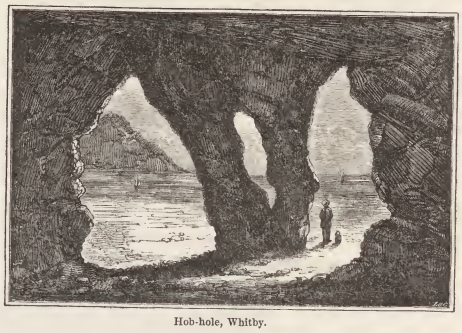
II. Springs and rivers officiate largely in either chemically corroding rocks and soils, or mechanically forcing particles asunder, transporting them to fresh sites by their currents; but river-floods sweep before them immense blocks, and plough their way through obstructions in their course.

It has been stated that a velocity of water, at the bottom of 6 inches per second, will move fine sand on a horizontal surface; 8 inches, sand as coarse as linseed; 12 inches, fine gravel; 24 inches, rounded gravel an inch in diameter; and 36 inches, angular fragments of the size of an egg.

Dr. Dana estimated the quantity of matter chemically and mechanically suspended in the Merimac River, United States, and brought past the town of Lowell during the year 1838, at 1,678,343,810lbs. avoirdupoise, the quantity of water discharged by the river during the same period amounting to 219,598,840,800 cubic feet. The deltas, which owe their origin to deposition from the rivers, are continually increasing by the constant supply of sediment. The delta of the Mississippi has advanced several leagues since New Orleans was built; that of the Nile has grown in some parts upwards of a mile since the 15th century; while the gain of land at the mouth of the Po has been from fifteen to twenty miles since the time of the first Roman emperors.

III. The action of the ocean by its waves and breakers upon abrupt coasts, especially when composed of rather yielding materials, is very powerful in wearing them away, and preparing detritus for the currents to convey to distant parts of its own bed. On the east side of England, there has been an extensive loss of land by this process since the dawn of authentic history; and within the memory of man, acres have been sown and reaped which are now the property of the sea. During storms, masses of rocks many tons in weight are sometimes wrenched from their ledges, and have been driven up a surface sloping with a considerable dip towards the ocean; while mounds protecting low-lying territories have been violently forced, and the areas beyond them permanently submerged.

The Abbey of Whitby, now about 200 yards from the edge of a perpendicular cliff, was a mile from the sea at its foundation in the year 658. In the same locality, the cave called Hob-hole, scooped by the waves, had a few years ago a double pillar at the entrance, now demolished by their play.



Hob-hole, Whitby.

Some idea may be formed of the changes wrought by the ocean in its angry moods in the course of a few thousand years, from the following chronicle of selected cases:

Years.

800. The sea carries off a large quantity of the soil of Heligoland, islands in the German Ocean, off the mouth of the Elbe, previously of considerable extent, but subsequently much reduced.

800—900. Tempests change the coasts of Brittany; valleys and villages are swallowed up. The Bretons have a tradition, which has descended from the fabulous ages, of the destruction of the south-western part of Brittany.

800—950. Violent storms agitate the Lagunes of Venice. The Isles of Ammiano and Constanziaco disappear.

1044—1309. Terrible irruptions of the Baltic on the coasts of Pomerania, which commit great ravages, and give rise to the popular rumour of the disappearance of the fabulous city of Vineta.

1106. Old Malamocca, a considerable town near Venice, engulfed by the sea.

1218. A great inundation formed, near the mouth of the Weser, the Gulf of Jadhe, so named from the small river which watered the fertile country destroyed by this catastrophe.

1219, 1220. Terrible storms form the island of Wieringen. This lies to the south of
1221, 1246. the Texel, and was part of the mainland of North Holland in the year
1251. 1205. It was detached from the continent by the high floods which occurred in the annexed years.

1277, 1278, Inundations engulf the fertile country of Reiderland, an alluvial plain at
1280, 1287. the mouth of the Ems in the time of the Romans, stretching between Groningen and East Friesland. Two small streams, the Tiam and the Eche, which watered this district, disappeared. The town of Torum, a considerable place, was destroyed, along with upwards of fifty market-towns, villages, and monasteries. A new gulf, called the Dollart, now occupies their site.

1282. Violent tempests break the isthmus which united Holland with Friesland, and form the Zuider Zee.

1240. An irruption considerably changes the western coast of Schleswig; many fertile territories are swallowed up, and the arm of the sea which separated the island of Nordstrand from the continent is greatly enlarged.

1300, 1500. Three-fourths of Heligoland are swept away.
1649.

1300. Ciparum, in Istria, destroyed.

1303. A great part of Rugen engulfed, and many villages on the coast of Pomerania.

1337. An inundation carries off fourteen villages in the Isle of Cadsand, in Zealand.

1421. An inundation covers a district named Bergseweld, in Holland, destroys twenty-two villages, and forms the Bies-bosch, a large sheet of water extending from Gertruidenberg to the isle of Dordrecht.

1475. Land near the mouth of the Humber swept away, and several villages destroyed.

1500. The parish of Bourgneuf, in Brittany, and several others in that neighbourhood, overflowed.

1510. The Baltic forms the mouth of the Frische Haff.

1530—1532. The sea engulfs the town of Kortgene, in the island of North Beveland. In the latter year the eastern portion of South Beveland is carried away, with several villages, and the towns of Borselen and Remerswalde.

1570. A violent storm destroys half of the village of Scheveningen, north-west of the Hague. The church, once in the middle of the village, now stands on the shore.

1625. The sea detaches part of the peninsula of Dars, in Swedish Pomerania, and forms of it the island of Zingst.

1634. An irruption submerges the whole island of Nordstrand, a large and populous district, which had originally been a part of the continent, and detached by a previous inroad of the waters. On the evening of the 11th of October, 1634, the sea broke over it, destroying 1358

Years.

houses, churches, and towns, 50,000 head of cattle, and upwards of 6000 persons. There now remains of this once flourishing and fertile island, the three islets named Pelworm, Nordstrend, and Lütze-moor.

1658. The island Orisant annihilated.

1719. Land torn away at Catwyck, which, though once far from the sea, is now upon the shore.

1726. A violent storm changes the Salt Marsh of Araya, in the province of Cumana, into a gulf several leagues wide.

1770—1785. Currents and tempests hollow out a channel between the high and the low parts of Heligoland, and transform into two islets this island, so extensive before the eighth century.

1784. A violent storm, according to M. Hoff, forms the lake of Aboukir, in Lower Egypt.

1791—1793. New irruptions destroy the dykes, and carry off other parts of the already reduced island of Nordstrand.

1803. The sea sweeps away the last remains of the priory of Crail, in Fifeshire.

IV. While the ocean thus encroaches upon the land to diminish its quantity, it tends in some instances to increase it. Where the coast is low, and the bottom sandy, the waves carry the sand forward, which becomes dry at every reflux of the tide; and as the habitual direction of the wind is from the sea, the loose particles are further conveyed inland, forming hillocks around stones and bushes, which increase into sand-hills, and are called *dunes* or *downs*.

This is a destructive gift from the ocean, converting fertile districts into sterile wastes. The ancient barony of Coubine, near the mouth of the Findhorn, in Scotland, once remarkable for its fertility, has been rendered unproductive and depopulated by invasions of sand. The old town of Bannow, on the coast of Wexford, Ireland, bears the name of the Irish Herculaneum, from being now buried beneath accumulations of sand, above which a square tube of masonry still peeps, believed to have been the massive chimney of the town-house. The coast of France from Brittany to the Pyrenees, especially below the Garonne, presents vast undulating tracts of sand, the gift of the Atlantic, on the advance inland.

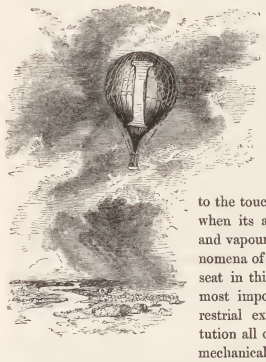
V. The waters tend in general to reduce the high grounds, and raise the low; to equalise the level of the land by the transport of matter torn from the more elevated parts to inferior sites; as well as perhaps to contract the habitable area of the globe by transference of its material to the floor of the ocean; but this tendency of aqueous action, is sufficiently counterbalanced by the upheaving force which operates upon the solid crust of our planet, and keeps up a due proportion between the areas of its dry and fluid portions.

Lancaster Sands.

METEOROLOGY.

CHAPTER I.

THE ATMOSPHERE,



S that stratum of gaseous matter which everywhere surrounds the earth, and is maintained at its surface by the force of gravity, while sharing in the orbital revolution and diurnal rotation of our globe. In consequence of the latter motion, it forms, when in equilibrio, an ellipsoid flattened at the poles. Unlike the great divisions of land and water, it is imperceptible to the touch, unless in agitation; and only visible when its aqueous particles are collected in clouds and vapours. Some of the most marvellous phenomena of the natural world have their source and seat in this fluid envelope. It performs also the most important functions in the economy of terrestrial existence; for upon its chemical constitution all organic life absolutely depends, while its mechanical agency, as indicated by winds and temperature, is not less essential to the preservation of the animal, vegetable, and human races.

The atmosphere consists of dry air and the vapour of water. The air is essentially composed of oxygen and nitrogen, in definite proportions; gases which are highly injurious when inhaled separately. Repeated analyses show that in 100 measures of pure atmospheric air, there are 20 or 21 volumes of oxygen, and 80 or 79 of nitrogen. But it is never absolutely pure. There is a minute and variable quantity of carbonic acid gas present, with the odoriferous matter of flowers, and other volatile substances. The amount of aqueous vapour fluctuates; but in the dryest weather, it is supposed by Dr. Ure to be at least 1 per cent. Under ordinary circumstances, the composition of 1000 parts of the atmosphere may be stated as follows:

Oxygen	210·0
Nitrogen	775·0
Aqueous Vapour . . .	14·2
Carbonic Acid . . .	0·8
	1000·0

In all regions of the globe, at all altitudes, and at all times, the atmosphere yields the same chemical results. Berthollet found the air of Egypt identical with that of France; and air collected on the summit of the loftiest mountains, Mont Blanc and Chimborazo, or brought down by Gay Lussac from the elevation of 21,735 feet, exhibited the same chemical composition as that analysed from the lowest valleys.

The quantity of carbonic acid gas in the air is, however, greater near the level of the sea in summer than in winter; greater during the night than the day; and rather more abundant on the summit of mountains than on the plains. It appears also, from the analysis of a young Danish chemist, M. Lewy, who collected the air as near as possible to the surface of the sea, during a voyage from Havre to Copenhagen, that this air, as compared with that of Copenhagen, presented a somewhat less proportion of oxygen.

It is true that the air of the densely populated city, and of such districts as the Pontine marshes, which brands with pallidness and premature old age the natives constantly exposed to it, cannot be the same as that which gives bloom to the cheek and vigour to the frame; but the difference is only known by these effects, chemical means having hitherto failed to detect it.

II. It was surmised as early as the age of Aristotle, that air had weight; but the verification of the fact did not occur until the former part of the seventeenth century. The atmosphere, it is now known, exerts a pressure or weight of about 15 pounds on every square inch of the earth's surface, which is equal to the weight of a column of mercury 1 inch square and 30 inches high, or a column of water of the same base, and 34 feet high.

The pressure of the atmosphere was noticed by Galileo, but demonstrated by his pupil, Toricelli, who invented the barometer, a simple instrument, consisting of a column of mercury, poised, or pressed upwards into a vacuum by the weight of the atmosphere.

The barometer shows the atmospheric pressure to vary according to the elevation above the level of the sea. The pressure diminishes as we ascend; hence the mercury falls; and making allowance for the increased rarity of the air with the greater altitude, the height of mountains may be estimated by barometric indications.

The pressure varies also in the same place owing to fluctuations of temperature, &c. This is indicated by the barometer. The mercury is commonly high in calm and fair weather; it falls when it is wet and stormy; and hence the use of the instrument as a weather-glass.

When the barometer is at 31 inches, the atmosphere presses on the surface of Great Britain with a weight equal to 291,793,239,406 tons; when it sinks to 27 inches, there is a diminution of weight on the same area equal to 37,648,938,386 tons; being about 427,231 tons on each square mile.

III. The atmosphere is in a high degree elastic, or possesses the property of occupying less space under the influence of certain forces, and returning to its original volume when the influence is withdrawn. Hence its density is not uniform, but diminishes from below upward, because the lower portions are compressed by the superincumbent air. The height of the atmosphere is not known, but it is supposed to extend to about fifty miles; yet by far the greater portion of it is within fifteen or twenty miles of the earth's surface; and at a much less distance it becomes so rarefied as to be incapable of supporting life.

In ascending high mountains, the rarity of the air sensibly diminishes the intensity of sound, renders respiration difficult, produces a loss of physical strength, and travellers have found it impossible to reach their crests. The blood burst from the ears and lips of Humboldt in attempting to reach a high elevation in the Andes. He experienced the same difficulty in kindling and maintaining a fire at great heights, which Marco Polo felt on the mountains of Central Asia. Captain Gerard, who crossed the Mannering Pass in the Himalaya, remarks, "Our elevation was now 16,000 feet, although we had but ascended in company with the river. Here only began our toils; we scaled the slope of the mountain very slowly; respiration was laborious, and we felt exhausted at every step. Our situation was different from anything we had yet experienced; it cannot be described. Long before we got up, our respiration became hurried and oppressive, and compelled us to sit down every few yards; and then only could we inhale a sufficient supply of air. The least motion was accompanied by debility and mental dejection."

The effect of the diminished density of the atmosphere on the heights of the Andes, is supposed to be a malady by the natives, due to exhalations from metals, and is called the *veta*. "The first symptoms of the veta," according to Tschudi, "are usually felt at the elevation of 12,600 feet above the sea. These symptoms are vertigo, dimness of sight and hearing, pains in the head, nausea, and blood flows from the eyes, nose, and lips."

IV. The atmosphere is naturally colourless. Its prevailing blue arises from the rays of the red extremity of the spectrum freely passing through it, while the blue rays undergo the greatest reflection. The hue of the sky, however, presents all imaginable shades, from deep blue in the zenith, to paler tinges and complete whiteness towards the horizon. This is owing to the blue tints in the zenith being darkened by the deep black of inter-planetary space, and lightened towards the horizon by the white vesicles of fog and vapour, which occur in the greatest abundance in that direction. The former cause explains the deeper hue of the sky as seen at great heights; a fact long observed by the shepherds and chamois-hunters of the Alps.

CHAPTER II.

CURRENTS OF THE ATMOSPHERE.

I. The varying attraction of the sun and moon occasions disturbances in the aërial ocean around us,—an alteration in the heights of vertical columns of air,—or atmospheric waves analogous to tidal phenomena; but the agitations with which we are familiar, or the winds, are chiefly owing to changes in the temperature of a portion of the air, and in the quantity of water which it holds in a state of vapour. The equilibrium of the atmosphere being broken, the particles of air are set in motion to restore the balance; and as the deranging causes act with varying intensity, the winds or currents created are diverse in power.

1. The effect of heat upon the air is to expand its volume and diminish its density. When any portion of the earth's surface is more heated than the surrounding districts, the air there ascends and blows over the adjoining cooler and denser strata, causing an upper outward current, while the colder and denser fluid rushes towards the spot where the balance has been lost by expansion, and a lower inward current is produced. If we open a door in winter communicating between a hot room and a cold space, there will be an upper current of air directed from the heated apartment, and a lower current flowing into it. The flame of a taper held near the ceiling will be directed from within outwards; it will be driven from without inwards if held towards the floor; and be upright and still if placed midway between the two positions.

Volcanic eruptions are frequently accompanied with violent storms. The heat of the volcano determines an ascending current, and the cool air rushes from all sides towards the mountain.

2. An addition of vapour to the atmosphere, causing a local increase in its density, produces currents flowing away from the district of evaporation; while an abstraction of it by showers of rain and snow, creates a partial vacuum, towards which the air rushes from all points of the compass.

II. To indicate the direction of the winds, the horizon is divided into various equal parts, and each current receives the name of the point of the horizon from whence it flows.

The horizon is usually divided into eight parts, the points being thus noted in meteorological registers:—N, north; N E, north-east; E, east; S E, south-east; S, south; S W, south-west; W, west; N W, north-west. Most meteorologists add eight intermediate points, making sixteen, thus:—N, north; N N E, north north-east; N E, north-east; E N E, east north-east; E, east; E S E, east south-east; S E, south-east; S S E, south south-east; S, south; S S W, south south-west; S W, south-west; W S W, west south-west; W, west; W N W, west north-west; N W, north-west; N N W, north north-west.

Müller observes, that although the changes in the direction of the wind appear on a superficial view to be utterly devoid of rule in our regions, yet attentive observers have long since made the remark, that winds generally succeed each other in the following order:

S, S W, W, N W, N, N E, E, S E, S.

A complete change of the wind, as from south to east, north, or west, passing over the intermediate points, is very rarely observed in Europe.

Currents of water and air are named inversely. An easterly stream is a flow of water *towards* that point of the horizon; an easterly wind is a flow of air *from* it.

III. There are atmospheric currents, the direction of which no point of the horizon will indicate, for miners have long been familiar with very strong ascending gusts before and during violent tempests.

The explanation is, that storms are almost always preceded or accompanied by a great fall in the barometric column. The atmospheric pressure becoming less, the air in the bowels of the earth expands, and ascends to the surface.—M. Kaemtz.

IV. Currents of air frequently move in contrary directions at different elevations. This is apparent from the course of the clouds being divergent from the one indicated by the weather-vane; and from the higher clouds passing in an opposite direction to those below them.

The occurrence of upper inverse currents is very decisively proved by the following circumstances:

The inhabitants of Barbadoes one day observed, to their astonishment, a shower of ashes fall from the sky. They came from the volcano of St. Vincent, which is situated to the west of their island. The ashes had been launched high in the air, and beer transported in the direction from west to east, opposite to the course of the trade wind blowing below.

On the 25th of February, 1835, the ashes emitted from the volcano of Cosiguina, in the state of Guatimala, were precipitated on the island of Jamaica, and fell in the streets of Kingston, which is situated to the N.E. of Guatimala, the trade wind blowing below to the west.

At the summit of the peak of Teneriffe west winds almost always prevail, while the inferior currents are from the N.E.; and the remark has often been made, that in the elevated parts of the Canary Islands a contrary wind has been experienced to that prevailing at the general surface.

Lunardi travelled at the rate of 70 miles an hour in his balloon, while at Edinburgh, where he ascended, the air was quite tranquil, and continued so throughout his expedition. Mr. Green, the aëronaut, in a communication to the Meteorological Society, states: "Several instances have occurred where I left the earth about noon, in a complete calm; and after rising between 3000 and 4000 feet, I entered a current from the N.W. which carried me above a mile per minute. I must here observe, that if I leave the earth with the wind at W. or S.W., I invariably find, at an elevation of from 3000 to 4000 feet, a current either W. by N., or S. by W. This fact the inhabitants of London have had repeated opportunities of witnessing, by the ascent of my two balloons at the same time from Vauxhall Gardens. Whenever there was sufficient difference in the elevations of them, that which attained the greatest altitude frequently descended in Kent, at the same time the under current carried the lower balloon into Essex."

V. The velocity of winds is open to sensible observation, by the force exerted upon our own body, and the impression made upon light pliable objects. But a variety of experiments have been made by the *anemometer*, an instrument con-

structed for the purpose, though serious difficulties attend this class of researches. The following are some results obtained by Smeaton:

Miles per Hour.	Feet per Second.	Perpendicular force on one Square Foot in Avoirdupois pounds and parts.	Characteristics.
1	1·47	·005	Hardly perceptible.
2	2·93	·020	Just perceptible.
3	4·4	·044	
4	5·87	·079	Gentle, pleasant wind.
5	7·33	·123	
10	14·67	·492	Brisk wind.
15	22	1·107	
20	29·34	1·968	Very brisk wind.
25	36·37	3·075	
30	44·01	4·429	High wind.
35	51·34	6·027	
40	58·68	7·873	Very high wind.
45	66·01	9·963	
50	73·35	12·300	Storm.
60	88·02	17·715	Great storm.
80	117·36	31·490	Hurricane.
100	147·7	49·200	Hurricane, carrying trees and buildings before it.

The great storm from the S.W., on the 29th of November, 1836, passed over London at ten o'clock in the morning; at the Hague at one o'clock; at Amsterdam at half-past one; at Embden at four; at Hamburgh at six; at Lubeck, Bleckede, and Salzwedel at seven; and finally, at Stettin at half-past nine in the evening; thus taking between ten and eleven hours to traverse the space which separates London from Stettin. Its velocity was about 120 feet per second, or upwards of 80 miles an hour. The cross and ball of St. Paul's vibrated fearfully, and were expected to fall. This storm appears to have commenced on the east coast of America. It traversed the Atlantic, reached Europe in the latitude of the English Channel, and was finally lost in Lithuania.

Winds are commonly the strongest in mountainous countries, owing to the obstacles presented by the surface, which determine aërial accumulations escaping in furious local currents through the valleys and gorges. In a similar manner, when the bed of a river becomes narrow, or impeded with rocks, violent currents are produced in all directions, even where the water, a few yards higher up, has but a gentle flow. The winds acquire a fury, of which no idea can be formed, in the valleys of the Swiss Alps, where they are known by the name of *foen*.

VI. Permanent breezes prevail within the tropics, called Trade winds, which maintain nearly the same direction and rate throughout the year. Their limits in the Atlantic ocean have been fixed by navigators with great precision. They are termed from their direction being from N.E., in the northern hemisphere, and from S.E. south of the line, the north and south-east trades; but both blow more decidedly from the east as the equator is approached. Between them is a zone styled the Region of Calms, in which a thick foggy air prevails, with frequent sudden and copious rains attended by thunder and lightning.

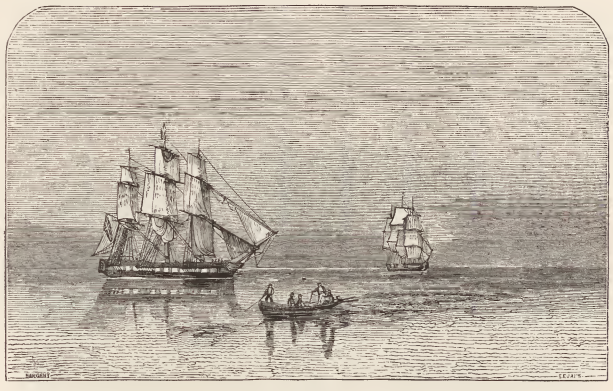
The north-east trade-wind prevails at a mean between 8° and 28° of north latitude. The limits of the south-east trade-wind are at a mean the parallels of 3° N. and 28° S.

The trade-winds may be readily explained. The regions bordering on the equator are the hottest on the earth. In consequence of rarefaction, the air there ascends, and flows over the colder masses on either side towards the poles, from which a colder atmosphere moves to supply its place. Thus two currents are created in each hemisphere, an upper and a lower, but flowing in opposite directions; and if the earth did not rotate upon its axis, the direction of the lower current in the northern hemisphere, or the trade-wind, would be from north to south, and in the southern hemisphere from south to north. The earth, however, rotates from west to east; and the atmosphere surrounding it partakes of this rotatory motion. Yet in proceeding from the poles to the equator, the masses of air flow from regions where the rotatory motion of the surface is less to where it is greater; and unable to acquire the new velocity at once, they are deflected towards the west just in proportion as they do not keep up with the surface towards the east. Hence instead of being north and south winds, which they would be if the earth were at rest, they become north-east and south-east winds.

The trade-winds would blow regularly round the entire globe within 30° of the equator on each side, but the uneven surface and unequal temperature of the land divert and derange them. Thus on the African side of the Atlantic, within a considerable distance of the land, they are not experienced at all, but contrary westerly winds prevail. This is owing to the rarefaction of the air over the hot desert of the Sahara, which creates a current of colder air blowing towards the shore. The Pacific ocean has regular trade-winds with the Atlantic; but in the Indian ocean they are interrupted by the monsoons. They are also experienced on equatorial lands which exhibit extensive levels, as in the basin of the Amazons, where a constant breeze is found, blowing from its estuary to its sources at the foot of the Andes.

While the north-east trade-wind, first discovered by Columbus, facilitated his course across the Atlantic, its constancy filled his companions with dismay, as it seemed to preclude the hope of their return to the shores they had quitted. The phrase *trade-winds* is supposed to have been applied to these breezes on account of their permanence and steadiness, *trade* originally signifying a common *course* or *track*, the *course treaded*. Hakluyt speaks of "the wind blowing trade," or a regular course.

Where the north-east and south-east trade-winds approach each other, they tend to produce a purely eastern breeze; but this is not perceptible, because the horizontal motion of the air is neutralised by the vertical motion consequent upon excessive heat and rarefaction. Here is the Region of Calms, in which there would be an almost perfect calm, but for the great evaporation and violent rains which disturb the equilibrium of the atmosphere, and occasion sudden storms and squalls. This zone, separating the trade-winds of both hemispheres, is entirely north of the equator, extending about 6° in width at a mean.



A Calm at Sea.

VII. Periodical winds, or those which regularly prevail at a certain time of the year or of the day, belong to various districts of the globe. The monsoons of the Indian ocean, the Etesian winds of the Mediterranean, and the land and sea breezes, are of this class.

1. *Monsoons.*—Throughout the year nearly, two winds are sweeping the surface of the Indian ocean and the adjoining land, blowing from different quarters and in different localities. From November to March, a N.E. wind reigns, north of the equator, making its appearance sooner in the Arabian than in the Bengal Sea, while at the same time, a N.W. wind blows south of the equator, between Madagascar, the Sunda isles, and the northern shores of Australia. From the middle of April to the end of September, north of the equator, a S.W. wind blows, and at the same time, a S.E. wind, south of the line. These are the monsoons, a term derived from the Malay *moussin*, signifying "a season." They last respectively about five months, there being two months in the year in which no monsoon is experienced, from the middle of March to the middle of April, and from the middle of September to the middle of October. The changes of the monsoons are effected during these intervals, in which calms and light breezes alternate with gales, hurricanes, and thunder-storms. It is a remarkable fact, that as soon as one monsoon ceases, though a month elapses before the succeeding one appears, the clouds at once take the direction of the approaching monsoon, and herald its coming to the regions below.

The N.E. and S.E. monsoons may be regarded as trade winds, explicable on the same principles, but counteracted for a certain time by causes which produce winds from a different quarter, or the S.W. and N.W. monsoons. The former, from S.W.

prevails coincidently with Bengal, Siam, and the adjacent countries, receiving their maximum of heat, occasioning a flow of cold air towards the region of rarefaction: the latter, from N.W., is coincident with the sun being vertical south of the equator, when the sandy plains of New Holland are powerfully heated, and the colder atmosphere is set in motion in that direction.

The monsoons are much stronger than the trade winds, frequently amounting to gales. They are also more serviceable to navigation, from the change in their direction, for a ship sailing with one monsoon to a distant port, may be aided on the return voyage by its successor.

2. *Etesian winds.*—The ancients gave this designation, signifying "annual" or "seasonal," to periodical winds which blow strongly from the north in the Mediterranean in summer. The immense desert of Sahara, south of the Mediterranean, deprived of water, and composed of sand and flints, becomes very highly heated under the influence of an almost vertical sun, and currents are created from the colder atmosphere of the north. Hence the passage from Europe to Africa in summer is much quicker than the return. Periodical currents, called *nortes*, or north-winds, blow from September to March in the Gulf of Mexico. They occur also on the Brazil coast, from N.E. in spring and S.E. in autumn.

3. *Land and Sea breezes.*—On the sea-shore, especially the coasts of tropical islands, a breeze from the sea is experienced a few hours after sunrise, owing to the land being more strongly heated than the sea by the sun's rays. At first light and scarcely perceptible, it increases till mid-day, is the strongest between two and three, P.M., afterwards dying away to a perfect calm at sunset. Soon after sunset, a breeze from the land commences, and continues till the morning, for at night the land rapidly cools, while the sea retains nearly the same temperature. Around spacious lakes, for the same reasons, there is a breeze from the lake by day, and towards it by night.

VIII. Variable winds prevail in mean and high latitudes, the same wind seldom lasting for several successive days. Designating the total number of winds that blow in a given time by 1000, the following Table shows their relative frequency in the countries named:

Countries.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
England	82	111	99	81	111	225	171	120
France	126	140	84	76	117	192	155	110
Germany	84	98	119	87	97	185	198	131
Denmark	65	98	100	129	92	198	161	156
Sweden	102	104	80	110	128	210	159	106
Prussia	99	191	81	130	98	143	166	192
N. America	96	116	49	108	123	197	101	210

The number of days in each month during which each wind prevailed at London, is indicated in the next Table, as registered at the Royal Society for a period of twenty years, ending 1846:

Months.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
January	2·8	4·7	3·7	2·4	4·5	5·7	4·0	2·9
February	2·2	3·3	3·2	2·0	4·4	5·8	5·1	2 1
March	2·5	4·8	2·9	1·8	3·2	6·5	6·0	3·0
April	4·0	4·9	3·5	2·1	3·4	5·0	3·5	3·1
May	2 4	6·4	5·2	1·2	5·0	5·1	3·1	1·5
June	1·4	3·4	2·3	1·4	4·7	7·1	6·2	3·0
July	1·2	2·1	2·8	0·9	4·1	9·0	7·1	2·8
August	1·2	3 2	2·8	1·1	5·2	7·4	7·2	2·7
September	1·5	3·1	2·7	1·5	6·4	6·3	6·1	2·1
October	1·6	3·7	2·5	1·5	6·1	6·6	5·4	3·2
November	1·2	3·8	3·2	2·2	5·2	7·1	4·4	2·6
December	1·9	3·4	1·5	2·5	4·5	8·3	6·1	2·5

This register shows that the south-west wind blows more frequently than any other during every month of the year, and that it is most common in July, August, November, and December. The number of days during which westerly and easterly winds blow in a year in different parts of Great Britain,—including under the term westerly the north-west, west, and south-west, and taking the term easterly with the same latitude,—has been thus registered:

Years of Observation.	Places.	Westerly.	Easterly.
10	London	233	132
7	Lancaster	216	149
51	Liverpool	190	175
9	Dumfries	227·5	137·5
10	Branxholm, Northumberland	232	133
7	Cambuslang	214	151
8	Hawkhill, near Edinburgh	229·5	155·5
	Mean	220·3	144·7

Thus, in Great Britain, Europe, and the north temperate zone, not only are the west winds more prevalent than the east, but their mean direction comes from the south-west quarter. Professor Daniel states that in our island, upon an average of ten years, the westerly winds exceed the easterly in the proportion of 225 to 140; and that the northerly exceed the southerly as 192 to 173. In the south temperate zone the mean direction of the prevalent winds is from the north-east. The hot air of the equator, which ascends and flows off towards the north and south poles, descends as it cools, meets the lower currents from the poles, prevails in the struggle.—variable but prevailing S.W. and N.W. winds in the respective hemispheres being the result.

IX. Winds may be further discriminated by certain physical properties, derived from the regions from which they proceed. Thus with us the west winds blow from the sea, and are much more moist than the east, which traverse the continent. In 100 showers observed at Berlin, the different winds blew in the following proportions:

N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
4·1	4·0	4·9	4·9	10·2	32·8	24·8	14·4

The atmospheric currents are also variously hot or cold, as they come from highly heated deserts and warm climates, or from snow-capt mountains, ice-bound seas, and high latitudes in general.

Cold winds.—The north, north-east, and east winds in our country are almost invariably cold; those between south and west are warm; and those between west and north are of a mixed character. South of the Alps the north winds are very cold, and frequently very violent, owing to the contrast between the snow-covered mountains and the elevated temperature of the Mediterranean. The *bora*, a north-east wind, so called in Istria and Dalmatia, is sometimes so furious as to overturn horses at plough. The same cause, the perpetual Alpine snows, renders the south wind so piercing in the valley of the Rhone, where it is styled the *vent de bise*.

Hot winds.—The burning deserts of Africa and Asia are the countries where hot winds occur in force; but in India, covered with luxuriant vegetation, in Chili, Louisiana, the llanos of the Orinoco, Spain, Sicily, Italy, and New Holland, winds of a very high temperature are frequent. They may be briefly noticed under local denominations.

Sand Storm in the Desert.

The *Samoom*, known in the deserts of Arabia, Nubia, Persia, and Syria, derives its name from its temperature and supposed pestilential character, the Arabic *samma* signifying at once hot and poisonous: the Turks call it *samiel*, which likewise means poison. But though dangerous and sometimes fatal in its effects, the pestilential and deadly attributes assigned to the blast may be deemed an oriental fiction. The dry soil of the desert becoming prodigiously heated, if a wind arises it must be burning. The fine sand and dust, frequently deeply tinged with oxide of iron, raised in the air, obscures the face of the sky, and gives to the whole atmosphere a dull fiery appearance; the sun loses its brilliance, and its light no longer projects a shadow. A rapid evaporation occurring at the surface of the human body dries the skin, accelerates

respiration, inflames the throat, and produces intense thirst. The water carried in skins by the caravans evaporates, and thus the simoom has been fatal to many overtaken by it since the expedition of Cambyses. A sufficient reason may be found for the Arabs covering their faces when it blows, and the camels turning their heads in the direction from it; viz., to avoid the flying sand, without imagining poison in the air. "In June, 1813," says Burckhardt, "in going from Siout to Esne, I was surprised by the *samoom* in the plain which separates Farschiout from Berdys. When the wind arose I was alone, mounted on my dromedary, and at a distance from every tree and habitation. I endeavoured to protect my face by wrapping it in a handkerchief. Meanwhile the dromedary, into whose eyes the wind drove the sand, became restless, commenced galloping, and caused me to lose the stirrups. I remained lying on the earth, without moving from the spot, for I could not see to a distance of ten metres, and I wrapped myself up in my clothes until the wind had abated. I then went to search after my dromedary, which I found at a very great distance, lying down near a bush, which protected his head against the sand raised by the wind." The samoom blows only occasionally, during intense heats, and seldom lasts longer than from a quarter of an hour to 20 minutes, though sometimes it continues for days.

The *Khamsin* (fifty) is the name given to a hot south wind, not so oppressive as the samoom, which blows in Egypt, continuing at intervals for a period of somewhat more or less than 50 days, from the end of April until June, at the commencement of the inundation of the Nile.

The *Harmattan*, experienced over Senegambia and Guinea, at intervals in December, January, and February, is an easterly wind, blowing from the Sahara, from which it derives an extraordinary degree of heat and dryness. It continues sometimes only for a day or two, but it has been known to last 15 or 16, and there are commonly three or four returns of it every season. A fog or haze always accompanies it, so dense that the sun is only visible for a few hours at noon. No dew falls while it lasts, nor is there the least appearance of moisture in the atmosphere. Vegetation consequently suffers; tender plants are destroyed, vigorous evergreens are withered, and the grass becomes like hay. To the human species the Harmattan is salubrious, though occasioning disagreeable sensations. It occurs after the rainy season on the African coast, during which diseases are induced by an excess of moisture, which its singular dryness removes from the atmosphere.

The *Sirocco*, the hot wind of Italy and Sicily, from the south, sometimes commences faintly about the time of the summer solstice, and occasionally blows with great force in July. Though usually attributed to the Sahara, it is supposed by Kaemtz to arise on the arid rocks of Sicily; and hence is far more violent on the north than on the south coast of the island, about Palermo, and also in the neighbourhood of Naples. The *Solano*, the hot wind of Spain, he refers likewise to the plains of Andalusia.

X. Storm-winds result from a very considerable disturbance in the equilibrium of the atmosphere, arising principally from a rapid condensation of vapour. When they occur upon a great scale, electricity is very powerfully developed with the precipitation of immense quantities of rain. Barometric oscillations indicate their approach. Scoresby affirms that he predicted tempests seventeen out of eighteen times, by consulting the barometer. They are generally observed at the period of the greatest heat of the day; but in the interior of continents and in mountainous countries nocturnal storms are by no means uncommon. It is stated by Eschwege, that no idea can be formed of the violence of a nocturnal storm in the virgin forests which clothe the mountains of Brazil.

XI. Tropical storms frequently exhibit terrific violence, tearing up forests, levelling solidly-built houses; and human life has been largely sacrificed in the war of elements. They are variously termed hurricanes, tornadoes, and tyfoons; seldom occur nearer the equator than 8° or 10°, or beyond the tropics; and are most tremendous in the vicinity of continents and islands. It appears from recent investigations that hurricanes, tornadoes, and tyfoons are to be regarded as great whirlwinds in motion, the meeting of two opposite winds producing the whirlwind. According to M. Dove, the rotatory motion of the air is from right to left in the northern hemisphere, or in a direction *opposite* to the hands of a watch; from left to right in the southern hemisphere, or *with* the hands of a watch; gusts and lulls occurring in the vortices. It is further ascertained that the northern hurricanes travel in an oblique direction from the equator towards the north pole, while the southern hurricanes move obliquely from the equator towards the south pole.

There are three well-known hurricane regions,—the West Indies, the Indian Ocean, and the Chinese Sea.

The general course of the West Indian hurricanes is from the Leeward Islands W.N.W., passing around the shores of the Gulf of Mexico or across it, then following the Gulf stream and terminating in the Atlantic, or exhausting their fury in the United States. From Oct. 3, 1780, to Aug. 25, 1837 inclusive, 38 hurricanes occurred in this region, in the following months: in June, 1; July, 4; August, 13; September, 10; October, 8; exclusive of 2, the months of which have not been recorded. Thus they are very rare in June; most frequent in August. The only instance in June occurred in 1831, when Trinidad, Tobago, and Grenada were devastated, before supposed to be exempt from hurricanes.

The hurricanes of the Indian Ocean come from the N.E., near Sumatra and Java, and travel to the S.W. towards Rodriguez and the Mauritius. They occur chiefly from December to April, the hot season in that hemisphere; are very rare in November and May; and are quite unknown during the other months of the year.

In the Chinese Sea, hurricanes, there styled tyfoons, range from the shore to about long. 150° E. They occur from June to November, after an interval of three or four years.

The progressive motion of hurricanes is very various in its rate, but very slow as compared with the rotatory velocity of the wind at the circumference. Their diameter has been noted at 1000 miles, and their track at 3000 miles.

XII. In mean and high latitudes storms are commonly far less extensive and violent than in tropical districts. There are, however, local storm regions, where the winds often blow with the fury of the hurricane, as in the Gulf stream, the vicinity of Cape Horn, and the territory of Buenos Ayres.

In the latter locality, the *pamperos*, or south-west winds, which originate among the snow of the Andes, rush with incredible velocity over the level pampas, and so suddenly set in that persons bathing in the Plata have been drowned, finding it impossible to regain the shore.

XIII. We frequently observe in serene hot weather the whirling motion of the air, betrayed by sand and dust ascending in spiral columns. Larger and stronger whirls carry up leaves and straw, and even buildings lying in their course. These whirlwinds are generally caused by the struggle of two winds meeting at an angle in the same manner that eddies and whirlpools are formed in water, by two currents being obliquely impelled against each other.

Commencement of the Monsoon.

Whirlwinds usually form a double cone. The upper cone has the vertex inclining downwards, while the point of the lower cone is directed upwards. In passing over the sea, lakes, and rivers, the water is raised by the lower cone in a spiral column, often to the height of several hundred feet, while the clouds are brought down by the upper cone, and a *water-spout* is formed. The two cones have frequently been observed to separate and re-unite; and in the Mediterranean as many as sixteen water-spouts have been seen at the same time. In water-spouts on land the upper cone consists of a mass of clouds, and the lower cone of sand, dust, and other bodies found on land. Deluges of rain accompany their disruption.

XIV. The winds perform a grand and important part in the economy of Nature. They moderate the severity of northern climates by bringing to them the heat of the south; promote the fecundation of flowers by agitating the branches of plants, at the same time diffusing the productions of the vegetable kingdom, by the transport of pollen and seeds, to great distances; and but for the aërial currents rain would be confined to maritime countries, the interior of continents becoming arid deserts. They serve also to renew the air of cities, where causes of vitiation largely operate, and prevent that stagnation of the atmosphere which tends physically and mentally to deteriorate the human race.

Goitre, a disease of the thyroid gland, ending in cretinism, a malady of the brain and nerves, attended with malformation of the skull, common in those valleys of the Alps and Pyrenees which are closely confined by rocky heights, is commonly ascribed to the air wanting free circulation, and thereby becoming in summer excessively heated and loaded with moisture. The philosophical traveller Erman found goitre prevalent, and a healthy breed of Russians brought in two centuries to the very brink of cretinism in certain parts of the valley of the Lena, where the strata of air are checked and confined between steep and parallel heights, producing a marked effect upon temperature and humidity in the district. He observes, "The atmospheric phenomena of the valley of the Lena recal to mind in every particular the excellent description of the Cretin valleys in the district of Salzburg, given by Wenzel. The luxuriant growth of trees, which Fodere found to accompany cretinism in the valley of Maurienne, distinguishes also all the hollows in the rocks along the valley of the Lena; for here, between the parallels of 55° and 57° 7′, and close to the coldest meridian on the earth, a variety and beauty in trees of the pine family must be allowed to be as remarkable as the pistacios and laurels at the foot of Mount Cenis. The goitres on the Lena are most conspicuous between 1115 and 645 French feet above the sea, showing another instance of agreement with experience in Europe, where the height of 1170 feet above the sea appears to be the most favourable for cretinism, and that of 795 feet to be the lowest limit of the phenomenon." Cretinism is said to be more recent in the Pyrenees than in the Alps; but it may be traced in them back to the eighth century, when it attacked the Visigoths, who had been driven by Clovis into the valleys of that chain.

Loch Achray.

CHAPTER III.

HYDROMETEORS.

I. Upon exposing a vessel of cold water in the open air on a hot day, the quantity of the fluid soon sensibly diminishes, or it evaporates, being converted by the heat into invisible vapour, and diffused through the air. In like manner evaporation transpires upon a grand scale from the great collections of water on the earth's surface, the oceans, lakes, and rivers, as well as from the moist ground, subject to diurnal and annual variations, because depending mainly upon temperature.

Diurnal variation.—In summer, and throughout the year, the quantity of vapour diffused through the air is at its minimum in the morning before sunrise. Evaporation increases as the temperature rises with the ascent of the sun; but before mid-day, or at nine o'clock according to Müller, ascending currents, occasioned by the strong heating of the ground, carry the vapours towards the upper parts of the atmosphere, so that the quantity of water contained in the lower strata of the air diminishes, without, however, attaining a minimum so low as that of the early morn, though the evaporation keeps pace with the increasing heat of the day. This diminution continues till towards 4 p.m., when the ascending current ceasing, the quantity of water in the lower strata of air again increases, till towards nine o'clock the decreasing temperature puts a stop to the further formation of vapour.

In winter, owing to the diminished power of the sun producing feeble ascending currents, there is but one maximum observed in the quantity of vapour, at about 2 P.M.; and one minimum, just before sunrise.

Annual variation.—In January the quantity of vapour, like the mean temperature of the air, is at its minimum; it increases from that period, and in July attains its maximum; it then decreases to the end of the year. It appears, however, from Professor Daniell's Table, that in the vicinity of London the largest amount of water is elevated into the atmosphere in June:

Month.	Inches.	Month.	Inches.
January	0·413	July	3·293
February	0·733	August	3·327
March	1·488	September	2·620
April	2·290	October	1·488
May	3·286	November	0·770
June	3·760	December	0·516

II. The amount of moisture in the air is an element on which the life of plants and animals as much depends as on temperature; and the character of the landscape, with the development of disease, is greatly influenced by the dryness or humidity of the atmosphere. The amount varies in different regions of the globe. As resulting from the action of heat on water, the quantity of vapour diminishes with the temperature from the equator to the poles. It decreases also as we pass from coasts into the interior of continents, the degress of temperature being the same, because in the one situation water is abundant, and in the other scarce.

That the air is habitually drier in continental than in maritime countries is confirmed in the interior of the United States, in the middle of the plains of the Orinoco, in the steppes of Siberia, the deserts of Asia and Africa, and the central parts of New Holland. The greater clearness of the sky in continental countries is a proof of the same fact.

In the temperate zone, in general, the annual evaporation is estimated at between 36 and 37 inches of water. In the torrid zone, at Guadaloupe, it has been found to amount to 97 inches, and at Cumana to 100 inches.

III. The air is only capable of receiving a certain quantity of vapour. Its capacity depends upon its temperature, and is invariable in its extent at the same temperature. When as much has been taken up as from its temperature it is capable of receiving, the air is said to be at the point of saturation, and any further supply is resolved into a fluid condition, or floats in a state of cloud and mist. When, too, the atmosphere is saturated, the least decrease of temperature is followed by the precipitation of moisture; hence arise aqueous or hydrometeors, which result from the same causes, but assume different forms,—as mists, clouds, rain, snow, hail, dew, and hoar-frost.

The varying capacity of the atmosphere to receive vapour removes an apparent discrepancy between our impressions and physical facts. Thus, when evaporation proceeds rapidly, and wet objects speedily become dry, as in summer, we say that the "air is dry," although the absolute quantity of water contained in the air is then at its maximum. But in summer, when the temperature is high, the capacity of the atmosphere to receive vapour is the greatest; and on an average it is further removed from the point of saturation at that period.

IV. Mists and fogs are formed when the air is saturated, and generally when the moist soil, or the water of lakes and rivers is warmer than the air, the vapours from which are immediately condensed, like the vapour of expired air in winter, which becomes condensed, and visible on its escape from the mouth. Mists differ in no respect from clouds except in position, being on the surface of the earth, instead of being suspended at a height in the atmosphere. Travellers, on the summit of high mountains, frequently remark upon the fog intercepting their view, while the inhabitants of the valleys below speak of clouds clothing the mountain crests.

The thick mists which prevail in the neighbourhood of Newfoundland arise from the warm waters of the Gulf stream, which flow to that locality, the temperature of which is much higher than that of the saturated air.

Soon after sunset, in calm and clear weather, mists are frequently formed over the beds of lakes and rivers, while the adjacent land is free from them. This arises from the land more rapidly losing its heat by radiation than the lake or river. The air over the land necessarily becomes the coldest; and when the situation of the ground is such as to bring the cold air of the land over the warmer water, a fog confined to its expanse ensues. On descending the Danube in June, Sir H. Davy found mist regularly forming over the river in the evening, when its temperature was from 3° to 6° higher than that of the air on its banks, and none at all when the temperature of the air on the banks surpassed that of the river. His observations below Passau, where the Inn and Ilz join the Danube, show the different state of the rivers as it respects fog, owing to their difference of temperature, that of the air being the same:

Temp. of the air on the banks.	Temp. of the rivers.	State of the rivers.
54	Danube 52°	Thick fog on the whole breadth.
	Inn, 56½°	Slight fog.
	Ilz, 56°	Haziness.

METEOROLOGY:—CLASSIFICATION AND HEIGHT OF CLOUDS.

Kaemtz, during the finest weather on the Faulhorn, observed the lakes of Switzerland covered with fogs of various densities. That over the lake of Zug was very thick, while a stratum of light vapour rested only partially upon Lake Brienz. The phenomenon occurred so frequently as not to be referrible to an accidental cause. He remarks, in explanation, that the Lake of Zug is very deep, while its feeding streams do not come directly from the region of eternal snows; that its temperature must therefore be higher than that of the Lake of Brienz, into which the Aar is precipitated immediately after having come from the glaciers of the Grimsel; that thus more vapour is raised from the Lake of Zug than from that of Brienz; and that at equal temperatures of the air the former is more easily covered with fog than the latter.

V. Clouds are masses of visible vapour like mists, occurring at a distance from the surface of the earth, floating under the direction of the winds, exhibiting an endlessly diversified outline, a very varying density, and appearing at different elevations. The denser clouds are usually formed towards noon, when the vapours are raised up by the ascending currents of air, and then condensed by the lower temperature of the upper regions. Notwithstanding the varied dispositions of clouds, they may be classified under a few principal types, first distinguished and named by Mr. Luke Howard.

CLASSIFICATION OF CLOUDS.

The following three primary forms are noticed. Mr. Foster's English names are placed beside the Latin nomenclature of Mr. Howard.

Cirrus—Curlcloud.—The cirrus is composed of white thin filaments, variously disposed, in the form of woolly hair, a crest of feathers, or slender net-work. These clouds are known in Germany under the name of *Windsbeume*, wind-trees. Their appearance often precedes a change of weather,—rain or wind in summer, frost or thaw in winter.

Cumulus—Stackencloud.—This modification of cloud, usually under the direction of the surface winds, presents itself in the form of a vast hemispherical heap of vapours, resting on an horizontal base; hence its name, *cumulus*, a heap or pile, and *stackencloud*, masses of vapour stacked into one enormous fabric. This may be called the summer-day cloud, from its frequent occurrence at that period, resembling a mountain of snow when lighted up by the beams of the sun. It usually begins to form early in the morning, enlarges as the day advances, attains its greatest magnitude when the temperature of the day is at its maximum, decreases as the sun declines, and breaks up towards sunset.

Stratus—Fallcloud.—This cloud consists of horizontal bands contiguous to the surface of the earth. It belongs to the night, forming at sunset and disappearing at sunrise.

To the above primary varieties four transition or composite forms are added,

Cirrocumulus—Sondercloud.—This name designates the feathery accumulated cloud, familiarly known as fleecy, intermediate between cirrus and cumulus. It consists of small orbicular patches, arranged in extensive beds, the component parts being quite distinct or asunder.

Cirrostratus—Wanecloud.—Bands of filaments more compacted than those of the cirrum compose this cloud, lying inclined, or disposed in horizontal strata. It is sometimes seen cutting the sun on the moon's disc with a dark line.

Cumulostratus—Twaincloud.—Two or more cumuli united together, and resting on a common stratum, form this cloud, the most magnificent variety, which often exhibits a copper tinge, indicating a highly electrical condition of the atmosphere, and precedes the thunder-storm. The cumulo-stratus is often seen cut by the cirro-stratus, as in the Plate.

Nimbus—Raincloud.—Any of the preceding modifications may pass over into the actual rainy cloud, first exhibiting a great increase of density and a bluish black tone of colour, then putting on a lighter shade, or gray obscurity, and becoming fringed at the edges.

HEIGHT OF CLOUDS.

The clouds are most frequently higher within the tropics than in the temperate zones; and in the temperate zones they are commonly higher in summer than in winter.

During five years, Mr. Crosthwaite examined the height of clouds, at Skiddaw, a mountain in Cumberland 3022 feet above the level of the sea. The number of observations made amounted to 5371. Of these, there were 3273 times in which there were clouds below the summit of Skiddaw; and 2098 times in which the clouds were either above it, or there were no clouds at all.

The *cirri* are the highest clouds. Dalton gives their range as frequently from 3 to 5 miles. Kaemtz's measurements at Halle assign to them also a frequent elevation of nearly 5 miles. He states, that during a stay of eleven weeks within sight of the Finsteraarhorn, upwards of 14,000 feet high, he never observed any *cirri* below the summit of the mountain. Travellers have often remarked, that on the most elevated peaks, these clouds appear the same as from the plains. It is highly probable that they consist of flakes of snow.

SUSPENSION OF CLOUDS.

Composed of vesicular vapours, or minute globules of water filled with air, resembling soap-bubbles, the suspension of the clouds aloft seems extraordinary, since they are specifically heavier than the medium in which they float.

A vesicle of vapour falls *in vacuo* with a great acquired rapidity. It falls also in a perfectly calm atmosphere, yet very slowly, experiencing resistance from the air. But in descending, the vesicles soon reach warmer strata of air which are not saturated, where they dissolve, and are lost to view; while, at the same time, new vesicles are formed above. Thus the component parts of a cloud are often slowly descending, and yet the cloud appears to be suspended motionless in the air, its lower limits being continually dissolved, and the upper renewed.

The agitations of the air, though moving in a horizontal direction, contribute to the suspension of the clouds, in the same manner that we observe dust and soap-bubbles borne to great heights and distances by the winds.

Ascending currents of heated air exert also a force directly opposed to the fall of clouds. Hence the mighty masses of cloud, *cumuli*, attain their greatest elevation about noon, when the temperature of the day is the highest, and the ascending current is the strongest. Towards evening, as the temperature declines, and the ascending current becomes feeble, these clouds descend, and are dissolved on reaching the lower and warmer regions of the atmosphere.

VI. Rain is produced by the continued condensation of vapour, its vesicles becoming larger and heavier, separate globules merging together, forming actual drops of water, which are precipitated towards the earth. Rain may have begun to fall, and yet not reach the ground, being resolved again into invisible vapour on arriving at strata of air removed from the point of saturation. For the same reason, rain-drops may become smaller in their descent, a portion being evaporated, and less rain arrive at the general surface than at a certain height. Usually the drops increase in their descent, bringing with them the low temperature of the upper regions, and condensing on their surface the vapour in the lower and warmer strata of the atmosphere. Hence a rain-gauge placed on the ground will collect a larger quantity of water in a given time than another placed at some height above it, the drops increasing by the condensed vapour added to them in the space between the two points.

At the Paris Observatory, there is a rain-gauge on the terrace at the roof of the building, and another on the ground in the court. The gauge of the terrace is 27 metres above that in the court, about 34 yards. During ten years, from 1817 to 1827, the mean annual depth of rain as observed in the court was 56·371 centimetres, or 22·21 inches; and as observed on the terrace 50·471 centimetres, or 19·88 inches.

VII. Instances of rain without clouds are by no means rare. They may occur when the equilibrium of the atmosphere in its upper regions is intensely disturbed by very cold and warm currents of air coming into collision, condensing the vapours into water without going through the transition state of vesicular vapour.

M. de Nevew was in a shower at Constantinople for ten minutes when the sky was perfectly serene. M. Babinet observed the same phenomenon at Paris, May 2, 1842. On the following May 11, M. Wartmann, while in the Rue de l'Hôtel de Ville at Geneva, was surprised by an unexpected and abundant shower, so as completely to wet the pavement of the street, while the most beautiful azure prevailed over head. He mentions the singular fact in a letter to M. Arago, that while the rain from a serene sky at Paris on May 2, consisted of very small and very cold drops, the similar rain at Geneva on the 11th, was formed of drops very large and warm.

VIII. The contents of a single shower vary greatly in different localities, and at different periods in the same place. Kaemtz states, that when the quantity of rain that falls per day exceeds three centimetres, less than an inch, the low plains of Europe are soon inundated.

The following are examples of very extraordinary showers:

1822. Oct. 25, at Genoa, 30 inches of rain fell in the 24 hours. The effects of this deluge in the neighbourhood were proportionate to the magnitude of the cause.
1826. Nov. 22, at Naples, in 37 minutes, Professor Fable observed a fall of $\frac{9}{10}$ of an inch.
1827. May 27, at Geneva, there fell 6 inches of rain in 3 hours.
1829. Aug. 3, at Perth, there fell $\frac{4}{5}$ of an inch in half an hour. At Huntly Lodge, $3\frac{3}{4}$ inches fell in 24 hours, or about $\frac{1}{6}$ of what annually falls in the district.
1839. June 4, at Brussels, a rain fell which was only very heavy for three hours, yet 112 millemetres, upwards of 4 inches were collected in the day, while from 1833 to 1838, not half that quantity had been known to fall at Brussels in the same time.
1841. ——, at Cuiseaux, a small town in the valley of the Saone, there fell 270 millimetres, about 11 inches, in 68 hours.

At Cayenne, Admiral Roussin collected 10 inches in 10 hours.

In excessively rainy seasons, especially when harvests are blighted, the ignorant are apt to infer a deterioration of climate. But on comparing different years, the annual amount of rain, like mean temperature, is remarkably stable.

IX. The following are general laws relative to the distribution of rain:—1. It decreases in quantity as we proceed from the equator towards the poles, because heat, the cause of vapour, diminishes. 2. It decreases as we pass from maritime to inland countries, because the land supplies a less quantity of vapour than the sea. 3. It decreases in the temperate zones, on eastern coasts as compared with the western, because the latter are first exposed to the western winds, which blow from the ocean, and discharge their moisture upon them; but within the tropics, it increases on eastern coasts as compared with the western, because of their exposure to the trade-winds. 4. More rain falls in mountainous regions than in level districts, because mountains arrest the course of the clouds, and a condensation of vapour ensues from collision with their cold summits.

METEOROLOGY:—GENERAL LAWS OF THE DISTRIBUTION OF RAIN.

1. The diminution of the average annual quantity of rain from the equator to the poles, appears from the Table, which contrasts the amount of places within the tropics and in mean or high latitudes:

Tropical Lat.	Inches.	Mean and High Lat.	Inches.
Mahabaleshwar, Western Ghauts	302·66	South Slope of the Alps	57·57
San Luis de Maranhao, Brazil	276·12	Charlestown, South Carolina	47·60
Parimaribo, Guyana	229·20	Rhone Valley	35·18
Sierre Leone, Guinea	189·69	North France and Belgium	22·47
Cape Haiti, St. Domingo	127·88	Sicily	23·55
Granada, Little Antilles	103·41	Rome	30·00
Adam's Peak, Ceylon	100·00	Geneva	42·06
Columbo, ditto	99·21	North Germany	20·35
Havannah, Cuba	90·66	England (Dalton's Mean)	31·03
Bombay	80·04	Petersburg	17·05
Macao, China	68·30	Uleaburg, Finland	13·05
Annual quantity of Rain within the Tropics of the New World	115 inches.	Annual quantity of Rain in the Temperate Zones of the New World (United States)	37 inches.
Annual quantity within the Tropics of the Old World	76 „	In the Temperate Zone of the Old World (Europe)	31⅜ „
Average for the Tropics generally	95½ „	Temperate Zone generally	34⅘ „

But though the amount of rain is greater within the tropics than in the temperate zone, the number of rainy days is less, because two seasons divide the year—wet and dry; and during the dry season, entire months frequently pass away without a drop falling or a cloud being seen.

In the temperate zone also, in passing from south to north, the number of rainy days increases, although the intensity of rain diminishes;

Annual number of rain days in the	North of Syria	54
„ „	Strait of Gibraltar	68
„ „	Plains of Lombardy	96
„ „	Buda, Hungary	112
„ „	Plains of Germany	141
„ „	England and West France	152
„ „	Poland	158
„ „	Petersburg	169
„ „	Netherlands	170
„ „	East of Ireland	208

Average of rain days throughout the year, according to Müller:

Southern Europe	120
Central „	146
Northern „	180

Though on the east side of Ireland the rainy days amount to 208 in the year, a far less quantity of rain descends than what falls at Gibraltar in 68 days.

2. The decrease of rain as we recede from the seashore, and penetrate into continents, is exemplified in the interior of the United States, of the llanos of the Orinoco, of the Siberian steppes, of Australia, and on comparing the amount of precipitation in inland and maritime countries. It declines from an annual fall of between 30 and 35 inches on the shores of Great Britain and France to from 15 to 13 inches as the borders of Asia are approached. Mountain chains produce several exceptions to this rule.

The annual number of rainy days decreases also with the increased distance from the sea.

West coast of France	152
Interior of France	147
Kasan, Plains of the Volga	90
Interior of Siberia	60

3. The greater moisture on western than eastern coasts in the temperate zone, appears in our part of the globe, on comparing the rain-fall on our western and eastern shores, and on the coast of the Atlantic in general with the interior of Europe.

4. The excess of rain in mountainous districts, as compared with the amount in adjoining low and level countries, is sometimes very striking. Thus the annual average at Coniston and Keswick, among the hills of North Lancashire and Cumberland, is 84 and 67½ inches, while 19 and 17 inches are registered for the flats of Norfolk and of Essex. On the plains of Great Britain the yearly amount of rain is 24·51, and among the mountain ranges 40·59 inches.

Proceeding from Paris to the Alps, the following differences occur in the annual amount of rain:

Paris	500 millimeters = 20 inches.
Valley of the Middle Rhine	21 „
Berne, at the foot of the Alps	43 „
Great St. Bernard, highest meteorological station in Europe	63 „

High mountain ranges sometimes occasion an excess of rain in the country on one side, while a vast reduction occurs on the other. Nowhere is this better exemplified than in Norway and Sweden, divided by the Scandinavian Alps. At Bergen, on the Norwegian coast, there fall annually 82·12 inches, or more than at any other city in Europe, and more than the amount at many places within the tropics. The clouds brought from the Atlantic by the prevailing south-west winds, are arrested by the mountains and confined in the fiords, where they accumulate, and lose their moisture, as it were, by mechanical compression, so that the sea winds discharge nearly all the water held in suspension in passing the mountains. Hence it frequently rains for entire days in Norway, while only a few drops fall in Sweden, on the opposite side of the chain; while the mean annual fall in the latter country is only 20 inches.

X. There are extensive tracts of the globe in which rain is unknown; in some districts it falls periodically; and in others, precipitation may be said to be constant:—1. The Rainless Regions of the New World comprise portions of California and Guatimala, the Mexican table-land, and the coast line of Peru: those of the Old World comprehend an immense territory, stretching from Morocco, through the Sahara, a part of Egypt, Arabia, and Persia, into Beloochistan, with another great zone, commencing north of the Hindoo-Koosh and Himalayas, including the table-land of Thibet, the desert of Gobi, and a portion of Mongolia. In these tracts there is either no rain at all, or only a very small quantity; so seldom occurring as to be quite a phenomenon. 2. The Regions of Periodical rain are within the tropics, and have seasons of extreme humidity alternating with excessive drought. The length of time of the rainy season differs in different districts, but lasts generally from three to five months. North of the equator, the rains fall during the northern declination of the sun, and commence south of the equator with its southern declination; except in India, where the rainy and dry seasons are regulated by the monsoons. 3. The Regions of Constant Precipitation, in which rain falls irrespective of times and seasons, at any hour of the day, or on any day of the year, are extra-tropical; except the Zone of Calms, a narrow belt between the periodic rains of the northern and southern hemispheres, in which heavy showers occur almost daily.

In the rainless regions, consisting for the most part of rocky and sandy deserts, precipitation is unknown, because, as Kaemtz remarks, the highly heated atmosphere does not contain sufficient moisture to admit of it, under any decrease of temperature.

The periodical rains commence at Panama, on the west coast of America, in the early days of March: in Africa, near the equator, and on the banks of the Orinoco, they begin in April: in the countries watered by the Senegal, and at San Blas in California, they begin in June. The violence of these tropical showers may be inferred from the large annual amount of rain, and from its fall being limited to a few months, and to a few hours during the day. The drops are enormous, very close together, and fall with such rapidity as to occasion a sensation of pain if they strike against the skin. Erxleben mentions drops of rain at the equator an inch in diameter. Though the nights are almost always serene, the showers occurring in the day time, yet in some districts it rains also in the night, and even more than during the day.

Beyond the tropics, where the periodicity of rain disappears, its quantity is not uniformly distributed throughout the year; but while some portions fall in each of the four seasons, the larger amount descends in some particular season. Thus, designating the annual quantity by 100, the following is the seasonal proportion at the places mentioned:

	Madeira.	Lisbon.	Mafra.
Winter	50·6	39·9	53·4
Spring	16·3	33·9	27·5
Summer	2·8	3·4	2·7
Autumn	30·8	22·8	16·4

The winter rains are here comparatively abundant, while the summer rains are insignificant. It is the same on the N.W. coast of Africa, and at the Canary Isles; but in Germany, at Petersburg, and in the interior of Siberia, a far larger quantity of rain falls in summer than in winter.

Europe may be divided into three provinces of seasonal predominant rains:

1. Province of the winter rains—comprising those portions of the continent which are nearest to Africa, the south of Portugal, of Spain, of Italy, and of Greece.

2. Province of the autumn rains—including the remainder of southern Europe, with the west and north coast of France, the Netherlands, Great Britain, and Norway.

3. Province of the summer rains—consisting of interior Europe, with Denmark Sweden, and Russia.

The Table shows the monthly amount of rain, in inches, in the year 1846, at the places mentioned.

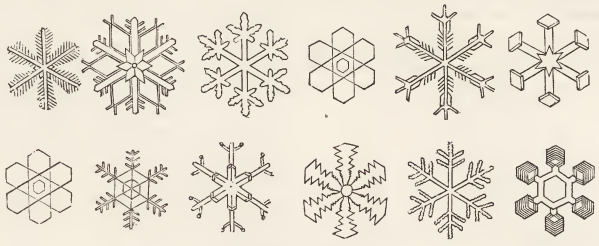
Places.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for the year.
Ackworth, Yorkshire	2·145	0·510	0·730	5·945	0·840	2·000	2·500	4·070	0·900	3·880	1·575	0·970	26·075
Chiswick, Middlesex	2·830	1·470	1·690	3·930	1·350	0·800	1·730	4·300	1·760	5·340	1·430	1·210	27·710
Empingham, Rutland	2·100	0·520	0·700	3·400	1·250	0·400	1·990	3·650	2·050	4·950	0·800	1·050	22·860
Epping, Essex	3·915	1·173	1·240	2·744	1·135	0·391	1·324	3·667	2·702	5·422	1·305	1·044	26·062
Falmouth, Cornwall	5·923	1·883	4·671	1·572	3·119	1·492	3·875	1·756	1·444	5·473	3·909	3·732	38·854
Greenwich, Kent	3·090	1·305	1 025	2·910	1·610	0·665	1·740	5·210	1·917	5·765	1·330	1·180	27·274
Keswick, Cumberland	5·112	4·840	8·542	4·546	1·724	4·710	9·320	4·076	2·902	12·248	6·472	2·586	67·678
Retford, Notts	2·375	0·280	1·360	5·550	1·145	0·875	3·450	4·175	1·750	3·900	0·785	0·575	26·220
Thwaite, Suffolk	2·620	0·710	0·810	3·150	1·100	0·680	1·790	2·940	1·520	3·260	1·020	0·860	20·470
Whitehaven, Cumberland	4·604	2·007	4·460	2·848	2·317	2·311	9·061	4·066	2·857	7·982	4·671	1·950	49·134

At the Royal Observatory, Greenwich, in 1846, there was collected by the rain-gauges:
177 feet above the level of the sea.. ..... 22·64 inches.
155 „ „ „ ..... 25·29 „
35 „ „ „ ..... 24·37 „

METEOROLOGY:—SNOW AND HAIL.

XI. Snow is nothing more than the frozen visible vapour of which the clouds are composed. A quantity of very minute crystals of ice having been formed, they are enlarged by the condensation and freezing of vapour, and merging together constitute flakes, which increase in size during the period of their descent. When the quantity of moisture separated from the atmosphere is not great, flakes are not formed, but the crystals remain detached, float in the air, and give rise to what is called the *frost smoke* observed in high latitudes. Snow falls to the ground when the temperature of the atmosphere down to the earth's surface is sufficiently cold; but if the lower strata of air are too warm it melts in traversing them, and then we have rain below while it snows above. Hence snow is never seen at the level of the sea within the torrid zone, and it becomes more abundant with the decrease of temperature towards the poles.

Flakes of snow are best observed when placed on objects of a dark colour, cooled below the freezing point, a method first described by Keppler, who expressed the highest admiration of their structure. The minute crystals exhibit an endless diversity of regular and beautiful forms, of which some examples are given, observed by Scoresby, who has described ninety-six varieties. Kaemtz states that he has met with at least twenty forms different from those figured by Scoresby; and they probably amount to several hundreds. It will be seen, however, at a glance, that the annexed forms are all essentially referable to a regular hexagonal star, and consequently snowflakes belong to the hexagonal system of crystals. Kaemtz observes that flakes which fall at the same time have generally the same form; but if there is an interval between two consecutive falls of snow, the forms of the second are observed to differ from those of the first, although always alike among themselves.



Various forms of Snow Crystals.

The limits of the fall of snow at the level of the sea in the northern hemisphere are generally the parallel of 30° in America, which cuts the southern part of the United States; 43° in the centre of the North Atlantic; and 36° in the Old World, the latitude of Algiers. But for some distance above these limits its appearance is rare and brief. The whole of Europe is included in the snowy region; but it becomes more abundant the further we recede from the Atlantic into the interior of the continent. Snowflakes never fall at Malta, are very infrequent at Gibraltar, and scarcely ever seen at Seville. The increase in the average annual number of days of snow from south to north is as follows:

	Days.		Days.
Rome	1½	Paris	12
Florence	1⅔	Carlsruhe	26
Venice	5⅔	Copenhagen	30
Milan	10	Petersburg	171

In February, 1836, a fall of snow occurred at Canton, in latitude 23° N., a fact without precedent in the memory of the oldest Chinaman.

Thunder Storm.

XII. Hail is one of the most obscure problems of meteorology. It no doubt often consists simply of raindrops more or less suddenly frozen by exposure to a temperature below the freezing point; yet true hailstones are not transparent ice, but have usually an opaque snowy nucleus, resembling a granule of sleet, sometimes coated with alternating layers of ice and snow. Sleet seems to be the germ of hail, changed in form and increased in size during its descent in the atmosphere. The great difficulty, however, is, that during fine seasons and the hottest days such intense cold should be suddenly produced as the phenomenon of hail indicates; and that certain countries, as some parts of France, should be almost annually ravaged by considerable falls of opaque ice, from which adjacent localities are almost wholly free. These are circumstances which have not been yet satisfactorily explained, though probably dependent upon electricity, which is almost always powerfully developed during hailstorms.

Hailstones are variously pear-shaped, flat, and angular; but most commonly rounded. When of considerable size they fall with great velocity, ploughing up the earth like musket balls, destroying the standing corn, stripping the trees of their foliage, penetrating the roofs of houses, and killing poultry, sheep, and even larger animals. Many instances are well authenticated of their circumference amounting from 6 to 9 inches, their weight from 12 to 14 ounces; but much larger masses are recorded. June 15, 1829, the hail beat in the roofs of the houses at Cazorta, in Spain,—some of the hailstones weighing 2 killogrammes, or upwards of 4lbs. avoirdupois. In Hungary, May 8, 1832, a block of ice fell, about 39 inches in breadth and length, and 27 inches in depth. An equally large block fell near Seringapatam, towards the close of the reign of Tippoo Saib. Mr. Darwin mentions a fall of hail in the state of Buenos Ayres which killed a large number of the wild animals, deer, and ostriches. These enormous masses are either the fragments of a thick sheet of ice suddenly formed, and broken in the atmosphere in falling, or they are due to the agglomeration of a great number of hailstones in their descent.

Hail falls most frequently by day, and soon after noon, at the time of the greatest diurnal heat. Nocturnal hail, especially towards midnight, is rare. Like rain, it is more common in some seasons of the year than in others. Associating hail and sleet, and representing the annual number of showers by 100, Kaemtz finds for the different seasons the following proportionate numbers:

	Winter.	Spring.	Summer.	Autumn.
England	45·5	29·5	3·0	22·0
France	32·8	39·4	7·0	20·7
Germany	10·3	46·7	29·4	13·6
Russia	9·9	35·5	50·6	13·0

Thus in England the relative amount of hail is large in winter and small in summer, while in Russia it is exactly the reverse.

A peculiar noise, distinct from that of thunder, has frequently been noticed a few seconds previous to the descent of hail. It is mentioned by Aristotle and Lucretius, among the ancients. Tessier heard it in France, July 13, 1788, when it was louder than the thunder and Kalm at Moscow, April 30, 1744; Peltier at Ham, in the

department of La Somme, heard a sound as if occasioned by the arrival of a squadron of cavalry at full gallop, immediately before a terrible hailstorm fell on the town. It is supposed to be due either to the conflict of contrary winds, or to the hailstones dashing violently against each other in their descent.

Hail showers are commonly over in a few minutes, very rarely lasting so long as a quarter of an hour, though the quantity of ice precipitated is sometimes enormous, covering the ground to the depth of several inches. The breadth of their course is often very narrow in proportion to its length. The storm of August 13, 1832, which came from Holland, traversed the Meuse, and destroyed all the crops along the Rhine through a space about 70 miles long, but not more than 6 or 7 miles wide. Tessier has minutely described the hailstorm of July 1788, memorable for the havoc it caused in France. It traversed the country from S.W. to N.E., in two parallel belts, extending from 400 to 500 miles in length, by a mean width of only 9 miles. The belts were distant from each other about 15 miles, and in this intermediate space no hail fell, but only heavy rain. Hail rarely occurs in higher latitudes than 60°. It is seldom seen within the tropics at the sea level. But at elevations of above 2000 feet it becomes more common, so that its rarity at a lower level is owing to the hailstones melting into rain as they descend.

Kaemtz has constructed an interesting Table, containing the dates of all the hail-showers in Germany and Switzerland he could collect, in order to show that hail falls at all hours of the day, but most frequently soon after noon, being most rare soon after midnight.

EPOCHS OF HAIL SHOWERS.

Hours.	Winter.	Spring.	Summer.	Autumn.	Total.
Noon	1	8	10	5	24
1	4	18	8	6	36
2	10	38	15	13	78
3	4	19	11	8	42
4	5	14	17	1	37
5	4	16	13	3	36
6	1	9	8	5	23
7	1	6	10	—	17
8	1	3	3	4	11
9	2	18	6	3	29
10	3	2	3	1	9
11	1	—	—	1	2
Midnight	—	—	2	—	2
13	—	—	1	—	1
14	—	—	2	—	2
15	—	—	—	1	1
16	1	—	—	—	1
17	2	2	—	1	5
18	1	1	—	—	2
19	7	13	3	6	29
20	4	3	1	2	10
21	3	6	2	—	11
22	2	8	3	1	14
23	1	10	4	5	20
Total	58	194	122	66	

XIII. Dew, the moisture precipitated during the night in the form of minute globules on the surface of plants and other bodies, is the effect of these bodies being cooled by nocturnal radiation several degrees below the temperature of the air in contact with them. Chilled by the cold embrace, the aërial particles are no longer able to support the same quantity of humidity in the state of transparent elastic vapour, and a portion is deposited. It is precisely the same phenomenon occurring on a great scale, as the precipitation of vapour on a bottle of wine taken from the cellar, or a decanter of water fresh filled from the well, and brought into a heated room.

The following are the chief circumstances connected with the formation of dew:

1. Dew is produced for the most part on calm and serene nights; an observation first recorded by Aristotle. The reason is, that only in the absence of clouds, is the radiation of the earth's heat towards the sky conducted so powerfully as to cool it sufficiently below the temperature of the contiguous air. When the heavens are overcast, the heat radiated, which would otherwise go off into free space, is returned by the clouds to the earth, and thus the necessary decrement in its temperature is prevented. There is no dew, however, when the sky is cloudless if the wind is brisk, because the air in contact with the soil suffers displacement before it can be cooled to the dew point. But a gentle motion of the air facilitates the disengagement of dew, by bringing fresh portions of the saturated atmosphere into contact with the cold surface of the earth.

2. Dew is formed most abundantly on objects perfectly exposed to the sky, for whatever acts as a shelter impedes radiation. Hence there is less dew in cities, where the houses screen the sky, than in the open country. Plants, also, placed under a tree are much less moistened than the grass in the middle of a field.

3. Dew is deposited much sooner and more abundantly on certain objects than on others, because all bodies have not the same capacity for radiating heat, some parting with it much more rapidly and perfectly than others. Hence some objects will be densely covered with dew, while on others adjoining it will be scarcely perceptible. Plants are sooner bedewed than the earth; sand sooner than hard soil; glass sooner than metals; and chips sooner than wood.

4. Dew is deposited during the whole night, circumstances continuing favourable, and not, as the ancients imagined, in the morning and evening only. When one portion of the air has yielded its moisture, it is removed, in consequence of that agitation which exists in the stillest state of the atmosphere, and succeeded by another having its quantity of water undiminished.

6. Dew is most abundant in maritime countries. The atmosphere, in the interior of large continents, has not the amount of humidity requisite for its production, except near great lakes or rivers. It forms most copiously with us in spring and autumn, because in these seasons there are the greatest differences in the temperatures of day and night. The average annual quantity over all Great Britain, is estimated at a depth of 5 inches, being about $\frac{1}{4}$th of the annual amount of precipitation, or about 22,161,337,355 tons, taking the ton at 252 imperial gallons.

The preceding remarks show the inaccuracy of the popular expressions of the dew falling or rising. It is simply deposited, it may be upon an *under* surface which nothing by falling can touch, or upon a *side* surface which nothing by falling or rising can reach.

The dew-point is the degree of the thermometer at which the vapour of water present in the atmosphere, on being exposed to a decrease of temperature, begins to be precipitated. It is the same as the point of saturation. At the Royal Observatory Greenwich, in 1846, the mean temperature of the dew-point was—in spring, 42·9; summer, 56·7; autumn, 48·4; winter, 36·7; and the year, 46·2.

XIV. Hoar-frost is the ice of dew. When the objects upon which the vapour of water is precipitated are cooled below 32°, the freezing point, the vapour can no longer be deposited in a fluid state, but in the form of icicles.

Snow Storm.

CHAPTER IV.

TEMPERATURE.

I. On observing the temperature of a place, as registered by the thermometer, it is found to be constantly fluctuating through a certain range, above and below a standard mean.

By the temperature of a place, meteorologists always mean, unless it is otherwise expressed, that of the air near the surface of the earth, as indicated by a thermometer efficiently protected from every kind of foreign influence.

Fahrenheit's thermometer is used by English observers; Reaumur's and the Centigrade on the continent; and as in translations of foreign scientific works, the degrees of the scale adopted are rarely converted into those to which the English reader is accustomed, it may be useful to compare their respective values.

Reaumur and the centigrade place the freezing point at 0, or zero; Fahrenheit, at 32. The boiling point on Reaumur's scale is marked 80; on the centigrade, 100; and on Fahrenheit, 212. Subtracting 32 from 212, we have 180° of Fahrenheit, equivalent to 100° centigrade, and 80° Reaumur. Each centigrade degree is therefore equal to $1\frac{4}{5}$°, or 1°·8; and each degree of Reaumur is equal to $2\frac{1}{4}$°, or 2°·25 of Fahrenheit. But after every conversion of the centigrade and Reaumur's degrees into Fahrenheit's, care must be taken to add 32° to that number, the freezing point of Fahrenheit, answering to 0, or zero, the freezing point of the foreign scales.

COMPARISON OF THERMOMETRICAL DEGREES.

Fahrenheit.		Centigrade.	Reaumur.
212°	water boils	100°	80°
200		93·33	74·66
180		82·22	65·77
160		71 11	56·88
140		60	48
120		48·88	39·11
100		37·77	30·22
80		26·66	21·33
60		15·55	12·44
50		10	8
40		4·44	3·55
32	water freezes	0	0
20		— 6·66	— 5·33
10		— 12·22	— 9·77
0		— 17 77	— 14·22

Degrees below the zero of each scale are termed negative, and are always preceded by the sign — *minus*. Those above the zero are termed positive, and are preceded by the sign + *plus*, or have no sign at all.

II. The temperature of the day in our latitudes is at its minimum a short time before sunrise, and attains its maximum about two o'clock in the afternoon, somewhat later in summer, and earlier in winter.

In hot climates, on the sea-coast, the maximum temperature frequently occurs before the culmination of the sun, because, about noon, a fresh breeze sets in from the sea, and lowers it.

III. The mean temperature of the day, is that which is equi-distant from the maximum and minimun. It is obtained by observing the thermometer at short intervals, as every hour, and dividing the sum of the degrees observed by the number of observations.

This is a laborious method, and experience has superseded the necessity for it.

A very correct result will be obtained by taking the mean of four readings of the thermometer, made at equi-distant hours. Thus, the sum of the degrees of temperature observed at 4 o'clock and 10 A.M., and at 4 and 10 P.M., divided by four, will give a value very little differing from the true mean. The result will be correct, according to Sir David Brewster, to $\frac{1}{10}$th of a degree.

M. Schouw recommends readings at 7 A.M., noon, and at 10 P.M., dividing the sum of the degrees by three, as a close approximation.

IV. When the mean temperature of all the days of the month has been found, the sum of the diurnal temperatures divided by the number of days, gives the mean temperature of the month. In like manner, the sum of the mean monthly temperatures in the year, divided by the number of months, gives the mean temperature of the year. The mean temperature of a place may be deduced with tolerable accuracy from a small number of annual means.

A very important result has been obtained from hourly observations at Leith, viz., that the half sum of the mean temperatures of homonymous hours, or hours of the same name, as 5 A.M. and 5 P.M., 6 and 6, &c., differs at an average only a quarter of a degree of Fahrenheit from the mean temperature of the year.

V. Temperature in equatorial regions is distributed tolerably equally over the whole year, owing to the days and nights being equal; but in mean and high latitudes, where the length of the day varies greatly, it takes a wide range above and below the annual mean. But in general, the mean annual temperatures vary very little.

DIFFERENCE BETWEEN SOME MINIMA AND MAXIMA TEMPERATURES.

Places.	Difference.	Authorities.
Rome	73°	Schouw.
Prague	109°	Strandt.
Paris	108°	Arago.
Stockholm	108°	Nicander, Ronnow.
Copenhagen	90°	Bugge.
Petersburg	117°	Euler.
Moscow	126°	Stritter.

There are greater differences. During the Russian expedition to Khiva, in 1840, the thermometer fell to −43° centigrade, = −45° 4′ Fahrenheit; and for more than three months the mean temperature was between 1° 4′ and −0° 4′ Fahrenheit. In June, the temperature rose to 46° centigrade, = 114° 8′ Fahrenheit. Thus, in the course of a few months, the troops were exposed to a variation of 89° centigrade, or 160° Fahrenheit.

The slight variation in the annual means appears from the following comparison of twenty years at Geneva:

Years.	Mean Temp.	Years.	Mean Temp.	Years.	Mean Temp.	Years.	Mean Temp.
1796	49° 3′	1801	51° 1′	1806	51° 4′	1811	51° 6′
1797	50 5	1802	50 5	1807	49 3	1812	47 8
1798	50 0	1803	50 4	1808	46 9	1813	48 6
1799	48 7	1804	51 1	1809	48 9	1814	48 2
1800	50 5	1805	47 8	1810	51 1	1815	50 0

The highest mean varies only 3° 58′ from the lowest.

At Paris, in the years between 1803 and 1813, the variations from the standard mean, never went beyond it more than 3° 4′, or fell short of it more than 2° 9′. The variable produce of our harvests is owing more to a change in the distribution of heat through the different months, than to any difference in the annual supply.

For the mean temperature of important places in different parts of the globe, see Meteorological Map. At the Royal Observatory, Greenwich, in 1846, the monthly mean was as follows:

January	43° 8′	July	67° 2′
February	44 2	August	65 5
March	44 9	September	61 7
April	49 1	October	51 6
May	57 1	November	45 2
June	67 8	December	32 6

The mean of the year . . . 52° 5′

VI. In our latitudes July is on an average the hottest month, and January the coldest; July the 26th the hottest day, and January the 14th the coldest; and the mean annual temperature generally occurs on the 24th of April, and the 21st of October.

The approximation of the mean temperature of October and April to the annual mean appears from the annexed comparison:

Places.	Mean Temperature. Of the Year.	Of October.	Of April.
Cairo	72° 5′	72° 3′	77° 9′
Algiers	69 8	72 1	62 6
Natchez	65 0	68 4	66 4
Rome	60 4	62 1	55 4
Milan	55 8	58 1	55 6
Cincinati	53 6	54 9	56 8
Philadelphia	53 4	54 0	53 6
New York	53 8	54 5	49 1
Pekin	52 8	55 4	57 0
Buda	51 1	52 3	49 1
London	50 7	52 3	49 8
Paris	51 4	51 3	48 2
Geneva	49 3	49 3	45 7
Dublin	48 6	48 7	45 3
Edinburgh	46 6	48 2	46 9
Gottingen	46 9	47 1	44 4
Franeker	52 3	54 9	50 0
Copenhagen	45 7	48 7	41 0
Stockholm	42 1	42 4	38 5
Christiana	41 5	39 2	42 6
Upsal	41 7	43 3	39 7
Quebec	40 0	42 8	39 6
Petersburg	38 2	39 0	37 0
Abo	40 3	41 0	40 8
Drontheim	41 7	39 2	34 3
Uleo	33 1	37 9	34 2
Umeo	35 8	37 8	34 0
North Cape	32 2	32 0	30 2
Enontekies	27 0	27 5	26 6
Nain	25 2	33 1	27 5

Thus, at Nain, on the coast of Labrador, the mean temperatures of October and April differ but little from the standard, 25° 2′, while the mean temperature of the warmest month, August, is 51° 80′, and of the coldest, February, — 11° 28′. At Petersburg, in October and April, the divergence is still less from the annual mean, 38° 2′, while the mean of the warmest month, July, is 65° 66′, and of the coldest, January, 8° 60′

METEOROLOGY:—SUBTERRANEAN TEMPERATURE.

VII. The Warmth Equator, or the line of the highest mean annual temperature, is not coincident with the geographical equator, but lies almost wholly to the north of it; occurring only to the south in the space between 150° W. long. in the Pacific Ocean and the Sunda Isles. It passes along the coasts of New Granada and Venezuela, in South America; intersects Africa from the Gulf of Guinea to the Abyssinian shore of the Red Sea; and cuts the extremities of the Arabian, Indian, and Malayan peninsulas. The minimum mean annual temperature, 81°, occurs in various places. The maximum, 87° 3′, the greatest heat hitherto observed, occurs at Massowah, in Abyssinia, in lat. 15° 36′ N., thus, much nearer to the northern tropic than to the equator.

VIII. Passing from the tropics towards the north pole, the temperature declines gradually, but much more rapidly in the new world than in the old, except under the eastern meridians of Asia, as shown in the following Table:

Latitude.	Temp. of the New World.	Temp. of Western Part of the Old.	Difference.
30°	66°·92	70°·52	3°·60
40°	54 ·50	63 ·14	8 ·64
50°	37 ·94	50 ·90	12 ·96
60°	23 ·72	40 ·64	16 ·92

IX. The lowest mean annual temperature, or greatest cold hitherto noticed, 1° 49′, was observed at Melville Island, lat. 70° 47′ N., during the celebrated northern expedition of Captain Parry, in 1819-20, and is deduced from observations made every two hours on board the Hecla, amounting to 4392. The mean temperature of the warmest month, July, was 42° 41′; of the coldest month, February, — 32° 17′. The maximum daily temperature took place at 2 P.M. on July 17th, and was 60°: the minimum was registered at 4 A.M. on February 15th, and was — 50°. But on the ice the lowest temperature registered was — 55°; and for seventeen hours on February 14th and 15th, the temperature did not rise above — 54°.

X. From the rapid decline of temperature in America and eastern Asia, as compared with Europe, it is inferred that the lowest temperature does not coincide with the geographical poles, but that not many degrees distant, and under meridians nearly at right angles with that which passes through the west of Europe, there are two points of greatest cold.

This idea, started by Sir David Brewster, has been adopted by Humboldt, Erman, Dalton, Kupffer, and generally.

The position of these remarkable points, Brewster conceives to be in 80° of north latitude, and in 95° of east, and 100° of west longitude. The mean temperature of the eastern or Siberian pole, is supposed to be 1°, and of the western or Canadian pole, —3½°. The Canadian pole being thus 4½° colder than the Siberian.

XI. The southern hemisphere is generally considered to be colder than the northern; but this only appears to be true in relation to its higher latitudes. Through the whole torrid zone, and down to about the parallel of 40° S., the temperature of the two hemispheres exhibits little or no discordance, but beyond this limit, towards the south pole, the cold rapidly increases.

Thus, Kerguelen Island, though only in latitude 48°, corresponding to that of central France, was found by Cook covered with snow in the height of summer. Sir James Ross speaks of a narrow belt of green grass running along the quiet shores; of vegetation only existing in scattered tufts higher on the hills, the plants being the same as inhabit a lower level; vegetation almost entirely ceasing at the elevation of 1000 or 1200 feet. The proportion of the surface covered with plants is about equal to that in Spitzbergen and Melville Island, at a higher latitude by 20° in the northern regions; but the relative number of species to individuals falls strikingly short; for whilst the flora of Melville Island boasts of 67 species of flowering plants, and Spitzbergen of 45, Kerguelen Island contains but 18, and of these only eight cover any considerable amount of the surface.

Along the south coast of South America, in the Gulf of Penas, lat. 46° 50′ S., a glacier descending to the sea-level, was found during the surveying voyage of the "Adventure" and "Beagle;" and according to Von Buch, the most southern European glacier that comes down to the sea, occurs on the coast of Norway, in lat. 67°, being upwards of 20° of latitude nearer to the north pole than the Gulf of Penas to the south.

To explain the lower temperature of the southern hemisphere, the astronomical cause has been assigned of the sun being a shorter time by 7¾ days on the south than on the north side of the equator. But this difference can have little effect, and is, moreover compensated by the earth being in perihelion, or nearer the sun during its south declination.

Kaemtz states the probable reason. In the northern hemisphere, the equatorial currents are urged towards the high latitudes by the prevailing S.W. winds: on the contrary, the current of the Indian seas, either returns into itself, or rounds the Cape, traversing the west coast of Africa, and cannot therefore heat the regions around the south pole. Again, the particular configuration of the South American continent, permits the Antarctic Ocean to flow freely towards the equator, carrying the circumpolarice into very low latitudes, and cooling the strata of air in contact with it.

XII. Geology furnishes incontestible evidence of the fact, that the globe has undergone extraordinary thermal changes, having once been a fused mass, its solid crust having arisen from the gradual refrigeration of this mass. We have also ample proof, that races of gigantic plants and animals allied to those of the tropics, altogether dependant upon a certain amount of temperature, once inhabited latitudes where no such productions now exist, or can exist. But whatever may have been the alternations of a long bygone period, it may be stated generally, that the conditions of superficial temperature at present subsisting have experienced no sensible change within the space of time embraced by history. On the one hand, if the earth has not yet reached its limit of cooling, the amount of refrigeration is not perceptible within any given time: on the other hand, the heating influence of the sun has no cumulative effect, but is alternately received and given off to the same amount.

In a paper on the "Thermometric State of the Globe," inserted in the French *Annuaire* for 1834, M. Arago concludes, that the general temperature of the mass of the earth has not varied $\frac{1}{10}$th of a degree for 2000 years; and that the changes we have observed, or think we observe, in certain climates, are not connected with cosmical causes, but with circumstances entirely local.

XIII. While from the phenomena of hot springs and volcanoes, and from the fact of the temperature in all countries increasing with the depth, it is inferred, that the centre of our planet is composed of matter in a state of fusion; it appears from the researches of Fourier and others, that this central focus of heat has no appreciable effect at the surface, and may be altogether neglected in inquiries concerning the temperature of the air. This must be owing to the want of conductibility in the rocks which compose the upper part of the crust of the globe.

XIV. The subject of subterranean temperature, a difficult point of inquiry, has been examined in natural excavations, mines, and Artesian wells, with some general results of interest, upon which dependence may be placed.

1. The effect of solar influence descends to a certain depth below the surface; and within that limit the temperature fluctuates with the periodical superficial fluctuations. The depth varies with the latitude, being least within the tropics, not much exceeding 1 foot, but amounting to 25 feet at Paris, and in several Prussian mining establishments to from 27 to 63 feet; much depending upon the nature of soils and rocks. Thus Professor Forbes states, that in the neighbourhood of Edinburgh, the effects of atmospheric temperature become insensible at the following depths in different substances:

Trap rock	55·5 feet
Sand	65·8 „
Sandstone	96·1 „

2. Throughout the entire globe, at a certain depth, a stratum of invariable temperature is met with, which neither solar influence from above, nor internal heat from below affects; and this temperature is proved to differ very little from the annual mean of the country at the surface. For more than half a century, the oscillations of the thermometer, in the caves of the Observatory at Paris, have not exceeded the $\frac{1}{133}$rd of a centesimal degree.

3. Below the stratum of invariable temperature, the causes of internal heat perceptibly elevate the thermometer, and proportionably as the depth increases. Differences in this respect are observed in different substrata. In Prussia, according to Von Dechen, the increase of temperature is in general much more rapid in coal than in metalliferous mines. Mr. Henwood also states, that at all depths in the mines of Cornwall and Devon, the rocks are warmer than the *lodes*, and the lodes than the *cross-veins*, while the working miners have long noticed, that at equal depths, the lodes containing tin-ores are colder than those in which copper-ores occur. The latter fact is known in Germany among the miners, who hold the prevailing opinion of stanniferous mountains being colder than others.

4. The ratio of the increase of temperature with the depth is affected by the nature of soils and rocks, and therefore varies; but in the bore of an Artesian well near Geneva, 727 feet below the surface, M.M. Marcet and De la Rive estimated it at about 1° of Fahrenheit for every 52 feet. Supposing this ratio to be maintained, it is clear that at a very trifling distance below the surface, compared with the earth's semi-diameter, the hardest substances must be in a molten state.

XV. The temperature of the medium in which the earth moves, or of interplanetary space, has not escaped the attention of philosophers. It is generally supposed not to differ much from — 58°, which is 90° below the freezing point of water; and to have but feeble influence upon the lower strata of the atmosphere.

The temperature of celestial space, as given above, is much inferior to the degree of cold which may be produced artificially, which amounts to — 91°, or 123° below the freezing point.

CHAPTER V.

CLIMATOLOGY.

WHEN enumerating the causes of climatic variation, or that diversity of temperature, humidity, and the phenomena of vegetation, which marks the surface of the globe, the *first* determining circumstance to be considered is the position of a country in relation to the sun, or its latitude.

II. The dependence of temperature upon the sun is open to daily observation. In proportion as this body advances above the horizon, the heat increases: it diminishes rapidly with its setting.

III. The calorific action of the sun is the most powerful when in the zenith of the observer. In that position, the solar rays traverse a smaller portion of the atmosphere, and a less quantity are absorbed, than when the position of the luminary is oblique, or at the horizon.

If we collect the solar rays in a burning-glass, in order to inflame tinder, more time will be required to light it as the sun declines in the heavens, and it will be impossible to produce ignition when within a few degrees of the horizon.

Kaemtz states, that when the height of the sun is 40° 30′ only two-thirds of the rays that impinge upon the atmosphere reach the earth: when at 21° 30′ only half; the rest being absorbed or reflected.

IV. It follows, that towards the equator, we have the greatest comparative amount of heat and the warmest climates, because at some point or other within the tropics the mid-day sun is always vertically above the heads of the inhabitants, his rays falling at the same time with but little obliquity upon the other points within those limits. It follows also, that heat generally diminishes with the increase of distance from the equator, because as we recede from that line towards the poles, the mid-day height of the sun becomes less and less, till his rays are too oblique to prevent nature from being chained in eternal ice, and render it capable of supporting vegetable life.

The time during which the sun is above and below the horizon, is an important element of climate. When the days are long, the continued solar action causes a powerful accumulation of heat, and the nights being short, but little of this heat is radiated. The effect of course is opposite in inverse circumstances.

LENGTH OF THE LONGEST DAY FOR DIFFERENT GEOGRAPHICAL LATITUDES.

Latitude.	Length of Longest Day.
0°	12 hours.
16 44′	13 ,,
30 48	14 ,,
49 22	16 ,,
63 23	20 ,,
66 32	24 ,,
67 23	1 month.
73 39	3 ,,
90	6 ,,

Under the equator, the days and nights being of equal length throughout the year, no great differences of temperature, or seasonal contrasts, are experienced.

There is but little variation also in the length of the day under the tropics. But in mean and high latitudes the inequality becomes great; and the long days coinciding with the northern declination of the sun when the solar rays fall less obliquely, and the short days with his southern declination when the opposite takes place, alternations of excessive heat and cold, or great seasonal contrasts, are produced. The further from the equator the more unequally is temperature diffused throughout the year, constituting what Buffon indicated by the name of "excessive" climates, where the winter and summer temperatures are in violent contrast. Grapes sometimes ripen in the open air at Quebec, while the freezing of mercury, which takes place at — 40°, is there no uncommon circumstance.

The long period during which the sun remains above the horizon renders the summer temperature sometimes quite oppressive, even within the limits of the arctic circle. In Norway, in lat. 70°, the thermometer has been observed to rise above 80°.

V. Supposing the globe to have a perfectly level surface, either of land or water, possessing the same character, the decrement of heat from the equator to the poles would coincide with the parallels of latitude, so that all places under the same parallel would have the same climate. But actual circumstances are far different from the postulate; and hence a *second* determining cause of climate is the elevation of the surface.

VI. It is well known from the experience of aëronauts, and of travellers who have ascended high summits, as well as from the occurrence of perpetual snow on the tops of mountains while oppressive heat is felt at their base, that the temperature of the air decreases with its height. This arises from the atmosphere not being heated by transmitting the rays of the sun, but receiving its heat solely from the warmed surface of the earth, and chiefly by actual contact. Hence its temperature becomes progressively lower with its distance from the general mass of the globe. Another reason is, its tenuity increasing with its elevation, the temperature of rarefied air being less raised by a given amount of heat, than that of the same portion of air when compressed.

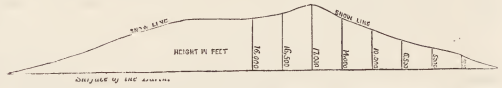
In general, the temperature decreases 1° for about every 352 feet; but the rate varies with the latitude, the season, and even the hour of the day. The decrease is greater in summer than in winter; more sensible in the afternoon than in the morning; and is affected by the presence or absence of hydrometeors.

VII. In every latitude, therefore, there is a limit in the atmosphere where the thermometer never rises above 32°, and consequently where ice and snow remain in the solid form. This limit, called the snow-line, or line of perpetual snow, or line of constant congelation, is the highest in the torrid zone, where the heat is the greatest. It rises to about 16,000 feet near the equator, and from thence descends generally in the form of a curve towards the poles, till it reaches the surface of the earth at about N. lat. 80°, but at a lower latitude in the southern hemisphere. The diagram represents the line of perpetual snow, forming the arc of an ellipsoid, passing over the equator from pole to pole.

The diagram but very distantly answers to this important boundary line in the atmosphere. Though osculating with the surface in high latitudes, and occurring at a considerable elevation in the torrid zone, it does not form a regular curve in its descent, but exhibits various inflections, suddenly rising or falling in several districts, owing to their physical peculiarities. Thus, it appears from the observations of Mr. Pentland, on the Bolivian Andes, that between 14° and 20° S. lat. the line of perpetual snow is higher than in the equatorial regions of the chain, and higher than in its Mexican prolongation at the same latitude in the northern hemisphere. The snow-line of the Andes under the equator descends to 15,748 feet, but not a particle of permanent snow was to be seen on the following sites, though in from 15° to 19° of S. latitude:

	Lat.	Elevation.
Cerro di Potosi, the summit of the celebrated metalliferous mountain	19° 36′	16,037 feet.
Mountain of Poreo	19 45	15,913 ,,
Mountain of La Golofa	16 42	16,250 ,,
Pass of Chullunquani	17 18	15,610 ,,
,, Las Gualillas	17 50	14,830 ,,
,, Los Altos di Toledo	16 2	15,528 ,,
,, Paquani	16 33	15,226 ,,
,, Leñas	19 16	14,203 ,,
,, La Compuerta or Lagunillas	15 · 52	15,613 ,,

Mr. Pentland found the mean elevation of the inferior limit of perpetual snow to be 17,200 feet on the volcano of Arequipa, in latitude 15° 20′, so that the snow-line of the Andes rises considerably south of the equator, roughly represented as follows:



A remarkable sudden fall of the Andean snow-line occurs farther south, exhibiting a difference of elevation of 9000 feet, within the distance of only 10° of latitude.

Place.	Latitude.	Height of Snow-line.	Authorities.
Cordillera of Central Chili	33° S.	14,500 to 15,000 feet	Gillies and Mr. Darwin.
Cordillera of Chiloe	43° S.	6,000 feet	Officers of the "Beagle" and Mr. Darwin.

This great flexure is attributed to the fact of Chiloe being covered with forest trees dripping with moisture, indicating a clouded sky and little heat in summer, while in Central Chila no rain falls for the seven summer months, the sky is generally clear and the climate hotter.

VIII. The line of perpetual snow sometimes varies in equal latitudes, because the summers are warmer in the interior of continents than on the coasts. Thus, though the Pyrenees and the Caucasus are under the same parallel, the snow-line

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on Mount Perdu in the Pyrenees was found by Raymond at the elevation of 8700 feet; but on Mount Elbrouz in the Caucasus, it only occurred at the height of 10,880 feet, according to Engelhart and Parrot. The same remark applies to the Scandinavian Alps, the snow-line being higher on the Swedish side of the chain, than on the Norwegian coast. The following Table, taken from the work of Humboldt on Central Asia, gives the heights of the eternal snows at different latitudes:

NORTHERN HEMISPHERE.

Places.	Latitudes.	Lower Limit of Perpetual Snow.
Norwegian Coast, Isle Mageroe	71° 15′N.	2400 feet.
Inner Norway	70°—70 15	3500 „
Inner Norway	67°—67 30	4200 „
Iceland, Oesterjokul	65 00	3100 „
Inner Norway	60°—62	5100 „
Siberia, Chain of Aldan	60 55	4500 „
North Ural	59 40	4800 „
Kamschatka, Volcano of Shevelutch	56 40	5200 „
Ounalaschka	53 44	3500 „
Altai	49° 15′—51 00	7000 „
Alps	45° 45′—46 00	8800 „
Caucasus, Elbrouz	43 21	11,100 „
„ Kazbek	„	10,600 „
Pyrenees	42° 30′—43 00	9000 „
Rocky Mountains	43 3	12,500 „
Ararat	39 42	14,200 „
Asia Minor, Mount Argæus	38 33	10,700 „
Bolor	37 30	17,000 „
Sicily, Etna	37 30	9,500 „
Spain, Sierra-Nevada of Granada	37 10	11,200 „
Hindoo-Koosh	34 30	13,000 „
Himalaya, North side	30° 15′—31 00	16,600 „
„ South side	„	13,000 „
Mexico	19°—19 15	14,800 „
Abyssinia	13 10	14,100 „
S. America, Sierra-Nevada de Merida	8 5	15,000 „
„ Volcano of Tolima	4 46	15,300 „
„ Volcano of Purace	2 18	15,400 „

EQUATOR.

Quito	0 0	15,800 „

SOUTHERN HEMISPHERE.

Andes of Quito	1°—1° 30′ S.	15,800 „
Bolivian Andes: Eastern Chain	14° 30′—18	15,900 „
Bolivian Andes: Western Chain	„	18,500 „
Chili, Volcano of Peuquenes	33	14,700 „
„ Andes along the Coast	41°—44	6000 „
Straits of Magellan	53°—54	3700 „

It will be seen from the Table that the line of eternal snow falls generally from the equator to the poles. But an important exception occurs on comparing the two sides of the Himalayan Mountains. The line is much higher on the north than on the south side of the chain, a parallel case to that of the Bolivian Andes, in the southern hemisphere, as compared with the chain near the equator. This fact was first ascertained by Humboldt, and though since doubted it has been amply confirmed. The south side of the Himalaya ascends abruptly from the low plains of Bengal, while the north side declines to the immensely elevated table-land of Thibet, and a higher temperature is produced, elevating the snow-line, by the solar action on the contiguous Thibetian plateau.

For the same reason, the cities of Mexico, Quito, Popayan, and Santa Fe de Bogota, seated on elevated plains, have a warmer climate than they would have at the same height if on isolated mountains.

IX. It is obvious therefore that countries which are at different elevations, though in the same latitude, must have different climates; and that in the same country there may be great diversity of climate co-existing, according as the surface is more or less elevated. Hence while the tropical valley or plain is oppressively hot, and loaded with luxuriant vegetation, if moisture is not wanting, the tropical mountain, rising a few thousand feet above it, in its higher regions, is as cold, and as bare of vegetation as any polar island. Successive zones, characterised by a different flora, mark the climatic variations resulting from a change of level.

Thus, in Mexico, where there are low coasts, high table-lands, and mountains covered with eternal snow, there are distinct and well-defined botanical districts:

1. *Tierras calientes*, the hot regions, including the country of the east and west shores below the height of 2000 feet, where bananas, the sugar, indigo, and cotton plants flourish luxuriantly—mean temperature about 77°.

2. *Tierras templadas*, the temperate regions, between the height of 2000 and 5000 feet, where oaks, cypresses, tree-ferns, and the cultivated cereals of Europe are encountered—mean temperature from 68° to 70°.

3. *Tierras frias*, the cold regions, above the height of 5000 feet, where the air is still genial to the elevation of 8000 feet, beyond which limit the climate soon becomes rigorous, fruits are not matured, wheat and oaks disappear, and pines occur.

In Switzerland, the beautiful vegetation in the valleys and on the plains at the foot of the Alps, vineyards, orchards, forest-trees, and cereals, have for the most part disappeared at the height of 6500 feet.

The vine, in the northern districts, does not rise higher than 1800 feet; but on the Italian side, as on the south declivity of St. Bernard, it attains to 3240 feet.

Barley ceases on the north side of Mont Rosa at 4200 feet, but reaches in a few spots on the south side to 6400 feet.

Fruit-trees, in the north, seldom pass above 2800 feet, but a few cherry-trees ascend on the Righi to upwards of 3000 feet.

The chestnut stops at about 2800 feet in the Pennine Alps. Walnut-trees attain about 3300 feet. The birch, larch, cembra, and alder, ascend as high as 7400 feet, on the south side of Mont Rosa.

PERPENDICULAR LIMIT OF TREES ON THE NORTH SIDE OF THE GRIMSEL.

CANTON OF VALAIS.

Hard oak. *Quercus robur*	2650 feet.
Beech. *Fagus silvatica*	3230 „
Cherry. *Cerasus vulgaris*	3476 „
Hazel. *Corylus avellana*	
Norway spruce fir. *Abies excelsa*	5070 „
Service. *Sorbus aucuparia*	5313 „
Scotch fir. *Pinus silvestris V montana*	5936 „
White birch. *Betula alba*	6479 „
Cembra pine. *Pinus cembra*	6889 „

Above the region of forest trees, there is the region of stunted pines, followed by the remarkable zone of rhododendrons covered with beautiful red flowers, beyond which is the region of the Alpine plants, and at a greater height only a few lichens appear. At the summit of the Jungfrau, elevation 12,872 feet, on the surface of the exposed gneiss rock, M. Agassiz, Professor Forbes, and their companions, found five species of lichens: 1. *Lecidea conglomerata*; 2. *Lecidea confluens*; 3. *Parmelia elegans a miniata*; 4. *Umbilicaria atropruinosa* γ *reticulata*. Saussure found the three last on Mount Blanc and the Col du Géant. 5. *Umbilicaria virginis*, a new species, so named by the lichenologist, M. Schærer, in commemoration of the ascent.

Approximate results of interest are expressed in the Table. The measures given are in fathoms:

	Andes of Quito. Lat. 0°	Mountains of Mexico. Lat. 20°	Caucasus. Lat. 42½.	Pyrenees. Lat. 42½°	Alps. Lat. 45½° 46°
Distance between trees and the line of perpetual snow	600	370	650	230	450
Upper limit of trees	1800	2000	1000	1170	920
Last species of trees towards the snow	Esculonia, Alstonia.	Pinus occident. The occidental pine covers the Nevado of Toluca.	Betule alba, common birch.	Pinus rubra. Pinus uncin.	Abies excelsa.
Distance between the snow and corn	800	...	630	...	700

X. The surface of the earth, consisting of land and water, we have a *third* cause of climatic variation in equal latitudes, in the position of countries being marine or continental. The ocean is not so rapidly heated, nor so soon deprived of the heat it has received, as the land. The temperature of its surface does not oscillate between such extreme heat and cold, but is far more uniform, lower in summer and higher in winter, than the temperature experienced in inland districts. The atmospheric currents that sweep over it, transfer the same character, to some extent, to the shores within their range. Hence littoral or maritime climates are more equable than the continental; for though both may have the same mean annual temperature, the range of the thermometer is far less on the coasts than at a distance from the sea. On the sea-side, the winters are mild and the summers cool, as compared with inland places, where the winters are cold and the summers hot.

Another cause contributing to the same effect is the immense evaporation from the sea, producing a frequently overcast sky along its shores. The clouds temper the solar influence in summer, and check radiation in winter.

The contiguous sea renders the summers of London cooler and the winters milder than those of Paris. Hence also the mild winters in the north-east of Ireland, where there is scarcely any ice or frost, in the same latitude as Konigsberg and Moscow. Edinburgh has the same mean annual temperature as Tubingen, or 46° 6′; but at Edinburgh the mean temperature of winter is 38°, and at Tubingen 31°; while that of the summer at Edinburgh is 57°, and of Tubingen 62°. With the same mean annual temperature, therefore, Edinburgh has a milder winter and a cooler summer than Tubingen. Along a line passing from the mouth of the Garonne, on the west coast of France, near Strasburg and Wurzburg, through Bohemia, the Ukraine, the country of the Don Cossacks, and north of the Caspian Sea, there is the same mean annual temperature; but the mean winter temperature differs widely along the line, being 42° at Bordeaux, 32° in Bohemia, 24° in the Ukraine, and 17° north of the Caspian Sea.

The annexed contrast shows the less range of temperature in littoral than in continental climates. The mean temperature of the year is placed first; the mean summer temperature above the horizontal line; and the mean winter temperature below.

Littoral Climate.			Continental Climate.		
	Y	43° 0′ S.		Y	60° 0′ S.
North Cape	32° 2′ . . .		Irkoutsk . . .	32° 0′ . .	
		23 0 W.			0 0 W.
		53 6			67 0
Reikiavig, Iceland,	41 7 . . .		Moscow . . .	38 5 . .	
		30 0			10 0

The contrast between places on the coast, and at but a short distance from it, shows the milder winter enjoyed at the former stations, as in France:

Places on the Coast.	Latitude.	Winter.	Summer.	Places on the Coast.	Latitude.	Winter.	Summer.
St. Malo	48° 39′	42° 4′	66° 9′	Chalons sur Marne.	48° 57′	36° 1′	66° 0′
St. Brieux	48 31	41 7	64 4	Paris	48 50	38 7	65 3
Vannes	47 39	39 7	64 4	Chartres	48 26	37 0	64 6
Nantes	47 13	40 5	68 5	Troyes	48 18	38 3	67 3
La Rochelle	46 14	40 3	66 6	Chinon	47 26	38 7	69 1
Gleron	45 56	44 6	68 5	Poitiers	46 39	39 7	67 1
Bordeaux	44 50	42 1	70 9	Vienne	45 31	38 7	71 6
Dax	43 53	44 4	67 3	Montauban	44 01	42 6	69 3

The circumstances stated have a marked effect on vegetation. On the coast of Devonshire, where the winter is not colder than at Florence and Montpelier, the *camellia japonica*, the *fuchsia coccinea*, and the *buddlea globosa*, live through it in the open air; and in the north-east of Ireland, the myrtle thrives as well as in Portugal, 15° further south. On the other hand, at Yakutsk, in Siberia, where the mean annual temperature is only 13° 8′, and the mean winter temperature is considerably under zero, the subsoil remaining constantly frozen at the depth of three feet, wheat and rye are raised, owing to a hot summer, while in Iceland, where the mean temperature of the year is very much higher, none of the cereals are raised, owing to the cool summer not allowing them to ripen.

Lines drawn through places of like summer temperature are termed isotheral, signifying equal summer; and lines connecting places of like winter temperature are called isochimenal, or equal winter.

XI. The prevailing winds to which a country is exposed form a *fourth* determining cause of its climate, because bringing with them a part of the properties of the quarters from whence they come, and the surface over which they have passed. In a calm state of the atmosphere, the effect of one region upon the temperature of another contiguous to it is probably small; but its colder or warmer air is transferred to the adjoining locality with the wind blowing in that direction, and the thermometer falls or rises.

With us, the north winds bring a very low temperature as compared with that which accompanies the south winds; and the thermometer rises or falls very regularly as the wind veers from north to south, or from south to north. In the higher latitudes, the change of temperature incident upon a change of the wind, is very great. Scoresby records an instance, in the neighbourhood of the polar ice, of the wind suddenly veering to the north, and of the thermometer falling in sixteen hours from 32° to −2° =34°.

At Bagdad and at Bushire, under the influence of the south wind heated by the burning sands of Arabia, the thermometer sometimes rises to 125°, and indicates the same degree of heat in Upper Egypt when the wind blows from the Desert.

XII. The soil of a country, and the aspect of a place, are also important constituents of climate. A surface consisting of sand admits of a higher degree of heat than clayey and compact soil, and bare grounds than pasture land. The effect of aspect is most strikingly seen in mountainous districts, where as a general law, vegetation ascends to a higher limit on the southern than on the northern declivities.

The walnut-tree, *Juglans regia*, in the Pennine Alps, rises to near 3500 feet on the south side, and to 3100 on the north. Trees in general ascend to 7400 feet on the south side of Mont Rosa, but do not pass beyond 6550 on the north. The zone of rhododendrons, *R ferrugineum*, and *R hirsutum*, at various points on the declivities of the Alps between Mont Rosa and Mont Blanc, has an altitudinal limit of 7830 feet on the south, and 6500 on the north.

The plants that are useful to man are sometimes carried higher on northern than on southern slopes, owing to differences of industry or skill in the inhabitants of the two sides of a range, or to the different estimation in which the products are held. This appears from the altitudinal limits of cultivated fields in the Pennine Alps.

Passes.	Most Elevated Villages. North Side.	Most Elevated Villages. South Side.	End of Cultivated Fields. North Side.	End of Cultivated Fields. South Side.
	Feet.		Feet.	Feet.
Col du Bonhomme .	Nant Bourant . 4670	Chapin . . .	3535	„	„
St. Bernard . . .	St. Pierre . . 5366	St. Remy . . .	5309	5530	5315
Col de la Fenêtre .	Lourtier . . 3496	Lomond . . .	3442	3756	5495
Mont Cervin . . .	Zermatt . . . 5296	Val Tornanche	5057	6509	5489
Col Macugnaga . .	Saas 5256	Macugnaga .	4264	5740	4264
Simplon	Baerensaal . . 5096	Simplon . . .	4933	3436	3280
Means . . .	4863		4443	4994	4769

XIII. Considerable deviations from the usual climatic state sometimes occur, spreading over wide districts, but it has been remarked, that no instance can be cited of a deviation extending to an entire hemisphere, so that it is highly probable, as before observed, that the same quantity of heat is always distributed over the earth's surface, although unequally. These peculiar atmospheric states are more frequently propagated in a meridional than in a parallel direction, opposite conditions subsisting under opposite meridians. The Danes have observed that unusually moderate winters in Iceland correspond to intense cold at Copenhagen. Generally speaking, the same deviation occurs in Europe and Asia, the opposite in America, or Asia and America are in opposite climatic conditions, while Europe is unaffected by either extreme. The more marked deviations from the usual range of heat occur more frequently in winter than in summer.

The winter of 1790-1 was very mild in Europe, and very cold in America.

The winters of 1794-5, when the Republican armies overran Holland, and of 1809, were very severe in Europe, and very mild in America.

In February, 1828, it was unusually mild in America, and very cold at Kasan and Irkutsk, while Europe was unaffected by the extremes.

In December, 1829, the cold was intense at Paris and Berlin, marked at Kasan, moderate at Irkutsk, while an unusual heat prevailed in North America.

In January, 1837, the temperature was mild in Europe, and very low in America.

XIV. While the general temperature of the globe appears to have suffered no perceptible change during the historic era, there is strong reason to suppose that the climatic condition of particular districts has undergone some gradual alterations. The climate of western Europe seems to have acquired a more genial character, seasons of intense cold occurring at more distant intervals than formerly, which may be due to the careful and vastly more extended cultivation of the soil, the extinction of bogs and morasses by drainage, and the destruction of the vast forests that once overspread the face of Gaul, Germany, and Britain. In the time of Cæsar, the rein-deer, now confined to the colder regions north of the Baltic, was located also on the south, together with the elk and the wild bull. The barbarians usually selected the winter season for their forays into the Roman provinces, when the great rivers were frozen, owing to the facility afforded by the ice for the passage of their armies, horses, and baggage. Marcus Aurelius signally defeated the Marcomanni as they were crossing the Danube, the action being partly fought upon its frozen surface.

CHAPTER VI.

ISOTHERMAL LINES.

I. Humboldt was the first to trace on charts lines connecting all points having the same mean annual temperature, or nearly. These lines are termed Isothermal, signifying equal heat. A distinct view is hereby afforded of the distribution of temperature; and the powerful operation of other causes besides latitude, in determining climate, will at once be seen on examining the curves. (See Map showing the Distribution of the Temperature of the Air).

If we suppose a traveller to journey from London to those places in the northern hemisphere which have the mean annual temperature of London, he would not travel along its parallel of latitude, 51½°, but proceed north-west through Ireland to lat. 55½°, descending south-west towards New York, lat. 40½°; and in the contrary direction, he would travel south-east to Vienna, lat. 48°, and the mouth of the Danube, lat. 44°.

II. Near the equator, the isothermals exhibit no great divergence from the parallels of latitude; but as we go further north, their inflections become remarkable, ranging through 20° and 25° of latitude.

1. The isothermal line indicating 80° of temperature, crosses Central America about the Gulf of Honduras, passes north of Jamaica, through St. Domingo, Porto Rico, descends to the west coast of Africa a little above Sierra Leone, ascends in that continent to the Tropic of Cancer, runs closely parallel to it through Arabia to Hindostan, descends in that peninsula, and cuts descendingly Siam and Cochin China, intersecting the group of the Philippines to the south.

2. The isothermal line of 70° cuts the Californian peninsula on the west coast of America about lat. 25°, falls below the Tropic of Cancer in the interior, rises on the opposite coast, passes by the delta of the Mississippi, through East Florida north of St. Augustine in about lat. 30°, reaches the west coast of Africa above the Canary Islands, ascends towards Tunis about lat. 34°, runs through the Mediterranean south of Candia, enters Syria north of Beirout, traverses Asia south of the Hindoo-Koosh and Himalaya Mountains, descends in China nearly to the tropic, and cuts the east coast of the continent about lat. 25°.

3. The isothermal line of 60° traverses America from the north of New California, near Port San Francisco, in about lat. 39°, to Nashville, lat. 36°, and a little below

Charlestown, falling in the interior. It rises then toward the north, reaches Europe about Cape Finisterre, lat. 46°, descends abruptly in the Spanish peninsula, but rounds the Gulf of Genoa, passes obliquely down Italy, intersects the south of Turkey, Asia Minor, passes by Tiflis, cuts the south of the Caspian, sinks in the interior of Asia, reaches its east coast about the mouth of the Hoang-Ho, and passes through Niphon, the largest of the Japanese group.

4. The isothermal line of 50° passes from Fort George, at the mouth of the Columbia River, lat. 46°, descendingly into the interior of America, rises to the southern extremity of Lake Michigan, and reaches the shores of the Atlantic near New York, lat. 41°. It then rises abruptly towards the north, attains lat. 56°, descends by Dublin, London, through midland Europe, passing near Dresden and Vienna to the mouth of the Danube, cuts the north of the Black and Caspian Seas, runs south of Lake Aral, falls in the interior of Asia, and rises on its east coast to lat 45°.

5. The isothermal line of 40° cuts the west coast of America north of New Archangel in about lat. 59°, descends to lat. 47°, passes Quebec, the south of Newfoundland, rises to lat. 69°, reaches the Norwegian coast about Drontheim, falls in the peninsula, declines to the south of Moscow, and sinks in Asia to lat. 47°, but rises on the east coast of the continent to about lat. 50°.

6. The isothermal line of 30° leaves the west coast of America in lat. 61°, rises to 64°, but soon declines, cuts the south of Hudson's Bay, and falls to lat. 53° on the shores of Labrador to the south of Nain. It then ascends abruptly to lat. 74°, and passing round the North Cape of Europe, as abruptly descends, cuts the White Sea in the latitude of the Arctic Circle, still further declines towards Asia, passes Irkoutsk, and falls to about lat. 50°, rising towards the east coast.

7. The isotherms indicating a lower degree of temperature can only be traced with certainty through portions of their course. That of 20° appears to descend from the mouth of the Mackenzie River, lat. 68°, to lat. 59° on the coast of Labrador. From thence it rises to lat 77°, cutting the south of Spitzbergen, and falls in Asia to lat. 56°. The isothermal line of 10° passes to the north of Hudson's Bay in America, and of Yakutsk in Asia.

III. The remarkable warmth of Western Europe, as compared with Eastern America and Asia, indicated by the great convexity of the isothermal lines about the meridian of Greenwich, has naturally attracted the attention of physical inquirers; and clear views have been obtained respecting the cause of the phenomenon.

1. The prevailing winds being from S.W., come from the equatorial districts, and partially bear the heat of the tropics to the shores of Europe.

2. The vast continent of Africa, bounding Europe on the south, consists to an immense extent of sandy deserts, rendered excessively hot under the vertical solar rays, from which a current of warm air rises continually to descend again in Europe.

3. The warm waters of the Gulf stream, which sweep across the Atlantic to the neighbourhood of Europe, and every year carry fruits and seeds belonging to the hot regions of America to the shores of Norway, notably elevate the temperature of the coasts that are washed by them, not only by the S.W. winds remaining long in contact with a current of heated water, but by the polar ice in its annual descent into the Atlantic being kept apart from the European shores. Shells of the tortoise, and portions of wreck, have often been drifted from the West Indies to the western islands of Scotland, as well as seeds of *Dolichos urens*, *Guilandina bonduc*, *G bonducella*, *Mimosa scandens*, and other plants of Jamaica, Cuba, and America. At Kielvig, near the North Cape, seeds of the *Mimosa scandens* are commonly found in the shingle, and are possessed by nearly all the fishermen.

North Cape.

4. The Gulf stream, it is true, runs along the east coast of America from Florida to Cape Hatteras, but the current is there very narrow, and the prevailing S.W. winds carry the hot circumambient air away from the shore. On the other hand, a sea current comes down from Spitzbergen, running between Iceland and Greenland, to the coasts of Labrador and Newfoundland, which contributes to depress the temperature by its cold waters, but chiefly by the floating icebergs that descend with it.

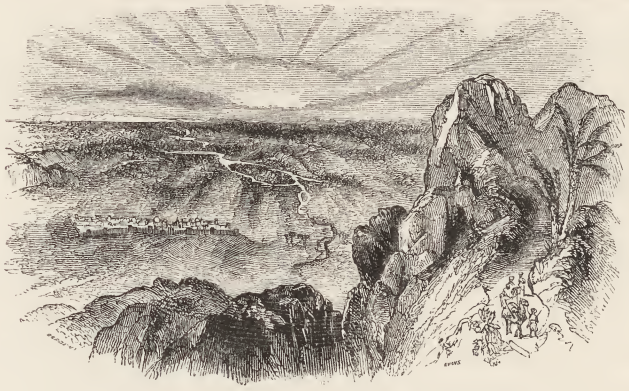
5. In Asia, there is no extensive tract of land, like Africa, within the tropics, but merely peninsular projections; and the air that is warmed in the basin of the Indian Ocean is prevented from reaching the interior and northern regions of the continent, by the mighty rampart of its central mountains. Asia also has a much greater extent of surface within the Arctic Circle than Europe; and the flatness of its northern districts, which present, however, a general northern declivity, leaves it open to the full operation of the polar cold.

IV. In defining accurately zones of climate, the astronomical lines of the Tropics of Cancer and Capricorn, and the arctic and antarctic circles, are practically useless, because of the divergence of the isothermal lines from the parallels of latitude. Attending only to the isotherms, we may discriminate five climatic zones—the hot, warm, temperate, cold, and frigid, shaded respectively on the map, deep and light carmine, green, light and deep blue.

V. The Hot Zone is bounded on each side of the warmth equator by the isotherm of 80°. It includes the north extremity of New Holland, the islands and peninsulas of Southern Asia, the middle regions of Africa, the north portion of Brazil, Guiana and Columbia in South America, and Guatimala in central America, with Jamaica and a part of the West Indian groups. In this region, at the sea level, frost and snow are unknown. Vegetation is luxuriant and perennial in the well-watered districts, but burning deserts of sand and flint prevail, altogether barren, except in a few cases, where moisture is wanting.

VI. The Warm Zone lies between the isotherms of 80° and 70°, and includes in

METEOROLOGY:—TEMPERATE, COLD, AND FRIGID CLIMATIC ZONES.



Plains of Beloochistan.

the northern hemisphere, Mexico, Cuba, Florida, north-west and northern Africa, excepting a portion of the Barbary States, Northern Arabia, almost the whole of Persia, Afghanistan, Beloochistan, Northern India, the Birman Empire, Siam, Cochin China, south of China Proper, and the greater part of the Philippine Islands. The characteristics of this region are much the same as those of the preceding. It embraces a vast area of bare rock and barren sand, where, as in Beloochistan, the summer heat is overpowering, with districts where the vegetable kingdom is luxuriant, favoured with a sufficient supply of moisture.

VII. The Temperate Zone is bounded by the isotherms of 70° and 30°; and includes a large section of North America and Central Asia, Iceland, almost the whole of Europe, and a small strip of Northern Africa. In its southern portion, we have the northern limit of the region of Palms, and the principal district of the cultivation of the vine. Its northern boundary in Europe nearly corresponds with the most northern limit of the cultivation of barley and rye, and the appearance of trees. In this zone, man has in all ages attained the highest development of his powers, and the most civilized nations have been located in it.

VIII. The Cold Zone is between the isotherms of 30° and 10°; and includes the countries around Hudson's Bay, most of Labrador, Greenland, Spitzbergen, Nova Zembla, part of Lapland, part of North Russia, and the most considerable portion of Siberia. Through great part of this region, the soil at a varying depth remains permanently frozen throughout the year, even in latitudes in Asia as low as that of London; but to a certain varying extent the surface is thawed by the powerful temperature of the brief Siberian summer, so that most of the cereals ripen, and harvests of wheat, barley, and rye, are gathered above subterranean sheets of eternal ice. In Asia also the oak maintains an existence on the southern borders of the zone, and some forest trees pass beyond its northern limit, their roots shooting below the frozen soil; though with reference to the larch and the arve, *Pinus cembra*, this is unnecessary, as recent inquiries have demonstrated that they survive even where the ground is perpetually frozen.

On the southern borders of this zone, at Nijnei Tagilsk, on the Asiatic side of the Urals, about the latitude of the Shetland Isles, the following temperatures, as observed by the thermometer in the year 1844, were submitted by M. Demidoff to the Paris Academy of Sciences:

In January . .	− 35°	In May	+ 14°	In September . .	+ 10°
„ February . .	− 50°	„ June	+ 29°	„ October . . .	+ 4°
„ March . . .	− 20°	„ July	+ 39°	„ November . .	− 31°
„ April . . .	− 10°	„ August . . .	+ 29°	„ December . .	− 37°

Thus there was only one month in the year, July, in which the thermometer did not sink below the freezing point, and no frost occurred.

The elder Gmelin was the first to state, in his travels in Siberia, that at Yakutsk, shortly after the foundation of that town, towards the end of the seventeenth century, the soil was found frozen to a depth of 91 feet, so that the inhabitants were obliged to give up the idea of sinking a well. Many similar statements were subsequently made of other localities; but in 1825, Von Buch, a philosopher of high authority in all physical questions, treated them as erroneous, remarking in a paper published in the Transactions of the Academy of Berlin: "I am fully convinced that the accounts of the soil being frozen in summer to the depth of many feet, in districts capable of maintaining the growth of shrubs and bushes, are not to be relied on." The fact has, however, been placed beyond all doubt by the inquiries of Humboldt, Erman, and others.

It has only recently been ascertained to what depth the stratum of frozen soil extends. For information upon this point we are indebted to M. Schargin, a merchant at Yakutsk. While the other inhabitants contented themselves with the water of the Lena in summer, and that of melted snow in winter, he commenced sinking a well, hoping to succeed in obtaining a supply, if the well could only be sunk deep enough, being quite convinced of the perpetual congelation of the soil immediately below the surface. When this chance failed, Admiral Von Wrangel encouraged him to proceed, in order to determine if possible the depth of the frozen stratum. The bottom of the shaft was 50 feet below the surface when visited by Erman, who buried the bulb of a thermometer at different places in the ground, but never saw the mercury in it rise above — 6° of Reaumur, or 18½° of Fahrenheit; thus showing a very decided winter temperature. The strata of fine sand and clays which formed the sides of the shaft were found uniformly frozen hard, so that instead of digging with the spade, it had been necessary to use the miner's pick-axe. The flakes and frozen pieces of earth in the interior of the well were perfectly dry, and had to be carried up into the warm air and thawed before they gave any signs of moisture.

The operations at Yakutsk have since been conducted to the depth of 382 feet, when the soil became so loose that it was impossible to proceed without timbering, which had not been necessary before, the ground indicating a temperature nearly 32°. The freezing point appears here to have been reached, so that in this part of Siberia, in lat. 62°, about that of Drontheim, in Norway, the layer of frozen soil has the immense thickness of not less than 382 feet. Erman remarks, that "the inhabitants of the Swiss Alps would not unjustly think themselves lost if they were compelled to live at the height of 10,000 feet, or 2300 feet above the Hospice of the Great St. Bernard, and there to support and to clothe themselves by keeping cattle, and with the productions of the surrounding mountains; yet they would then, and not until they arrived at that height, be settled on ground having the same temperature which I found here among the Yakutsks, who are rich in cattle. It would seem, therefore, as if that succeeded in Siberia which is impossible in Europe." At Yakutsk, while the annual mean temperature of the air is nearly 19° below the freezing point, and while in ordinary years a degree of cold is experienced from Dec. 17th to Feb. 18th exceeding 26° below zero, so that mercury is a solid body for two entire months, yet there are noble larch forests east of the town, while useful vegetables are raised in the gardens, and several kinds of grain produce on an average fifteen fold. This is explained by the short warm summer, which thaws the fields resting on perpetually frozen strata to the depth of three feet. There are 128 days in the year without frost; 92 days, those of June, July, and August, the mean warmth of which is 61°; and in the mountainous districts and northern countries of Europe, the cultivation of corn does not cease so long as none of the three summer months has a temperature less than 47°.

IX. The Frigid Zone is bounded by the isotherm of 10°. It includes the countries in America to the north of Hudson's Bay, and a section of Northern Asia, between the Gulf of Obi, in about long. 80° E., and the meridian of 160°, and between the mean latitude of 66° and the Icy Sea or Arctic Ocean. The isothermal lines of America and Asia in these high latitudes are not consecutive, but entirely separate, surrounding the two poles of maximum cold, neither of which coincides with the pole of the earth's diurnal motion. It is supposed that two similar poles exist in the southern hemisphere, but observations are wanting to verify the fact. The effect of cold upon vegetation is most apparent in this zone. The larch and birch pass within its limits, but they are stunted in form, and soon disappear. Hedenström admirably depicts the aspect of the Asiatic frozen regions:

"With painful feelings," he commences, "the traveller observes the trees diminishing in height as he approaches the shores of the Icy Sea. At Werchojantsk, 90 German miles from the sea, (upwards of 300 English) erect and lofty larch-trees afford a veil to expiring nature; but from this place their number decreases, and they become small and crippled. The coating of moss which covers the tree is thicker than the stem itself, but nothing can save it from the destroying breath of the north. Some thin birches endeavour to contend against this fearful foe, but they perish when scarcely sprung from the bosom of mother earth. It is only the moss, the true child of the north, which thrives and blooms even in the midst of winter, and scantily covers a soil which has been barren for thousands of years. From the last tree to the Icy Sea extends an enormous desert covered with lakes and lagunes, their banks consisting of alternating beds of earth and of ice. The beds of ice are generally perfectly level, as are also the beds of earth, which the ice immediately covers. Veins of ice which occasionally descend precipitously downwards, are of more modern formation. They arise from the fracture of the entire mass, and from the snow water which fills up the space thus left void."

CHAPTER VII.

ELECTRICAL PHENOMENA.

I. Of electricity in itself we know nothing more than that it is a mighty imponderable agent, called simply for convenience a fluid, invisible when in a latent state, apparently universally diffused, and capable of penetrating the pores, or even the substance of matter. It may be roused from a neutral condition and made visible, displaying tremendous energies, and producing destructive effects, by a variety of causes, as friction, heat, and chemical action, but we are totally ignorant of the reason why these causes elicit it. Information on the theory and details of electrical science must be sought in treatises specially devoted to the subject. In meteorology, we have merely to deal with it as developed in the atmosphere, its phenomena, effects, and distribution. But the statement of a few general principles may be expedient.

There are two kinds of electricity, each having its peculiar properties, but whether there are really two different electricities, or one electric fluid, which displays peculiar properties according as it is found in superabundance or deficiency, is a point upon which philosophers are not agreed, and either hypothesis will equally explain the facts observed. The discovery of the two kinds was made by Dufay in 1773.

Bodies in one electric state attract, and in another repel each other. The electricity in the former case is called *vitreous* or *positive:* in the latter, *resinous* or *negative.*

Bodies having positive and negative electricity in equal diffusion, or in a state of equilibrium, neither attract nor repel. This is their ordinary and natural condition.

When the equilibrium is destroyed, and the two electricities or electric energies are partially separated, as by friction, heat, and chemical action, their peculiar powers become manifest.

Two bodies charged with the same kind of electricity, brought into the vicinity of each other, mutually repel.

Two bodies charged with different kinds of electricity mutually attract.

In the case of two neighbouring bodies differently yet highly electricised, the one body imparts a portion of its electricity to the other, which returns an equal quantity of its antagonist element, and the derangement is equalised, the natural state restored. The two electricities coalesce with immense rapidity, causing a flash and an explosion, upon which the electric fluid returns to a latent and neutral condition, till a fresh derangement in the distribution is produced.

Though, strictly speaking, there is no known substance perfectly impervious to electricity and which offers no resistance to its passage, there is a certain class of substances through which it passes with greater facility, as metals, water, the human body, &c., than through others, as glass, silk, atmospheric air, &c. The former substances are therefore styled *conductors:* the latter, *non-conductors.*

In conductors, it is impossible for electricity to accumulate unless they are surrounded with non-conductors. They are then said to be insulated.

II. While the earth itself is always charged with negative electricity, the atmosphere, in a cloudless and clear state of the sky, is almost invariably found to be positively electric. But its electricity varies in intensity, being greater in winter than in summer, during the day than by night, and subject also to a kind of diurnal flux and reflux. From sunrise, when the atmospheric electricity is feeble, it increases for two or three hours, and attains its maximum. It declines towards the middle of the day, and attains its minimum in the afternoon. It then advances sensibly till about sunset, and attains a second maximum usually equalling that of the morning, but lasting a shorter time; after which it decreases slowly through the night.

These regular oscillations can only be traced in calm and serene weather, for the electrical state of the atmosphere is very uncertain with an unsettled sky, and changing temperature, being modified in a brief interval by whatever affects its thermometric and vaporous condition.

According to a careful observer, Mr. Crosse of Bloomfield, the comparative intensity of the electricity of the atmosphere in different states of the weather, follows the order of the arrangement in the annexed Table:

1. Regular thunder clouds.
2. Driving fog, with small rain.
3. Fall of snow, or brisk hailstorm.
4. A smart shower, in a hot day.
5. A smart shower, in a cold day.
6. Hot weather, after some wet days.
7. Wet weather, after some dry days.
8. Clear frosty weather.
9. Clear warm weather.
10. Sky obscured by clouds.
11. Mackerel, or mottled sky.
12. Sultry weather, with light hazy clouds.
13. Cold damp night.
14. Cold dry N.E. winds, affecting the feeling to a degree not corresponding with the thermometer.

III. The electricity of the atmosphere is supposed to be principally due to combustion, vegetation, and chemical action.

1. In the combustion of coal, wood, and other substances, the current of carbonic acid formed escapes in a state of positive electricity, the unconsumed portions remaining in the negative state.

2. Growing plants are affirmed by M. Pouillet to pour a great proportion of positive electricity into the atmosphere, which is carried off by the carbonic acid they exhale, while the vessels through which the gas escapes remain in the negative state. So considerable is this cause, that according to the same authority, the positive electricity evolved in a single day from an area of vegetation consisting of 600 square yards, would be sufficient to charge a powerful battery.

3. Among chemical actions, as the source of atmospheric electricity, the first place is due to evaporation in the circumstances in which it generally takes place. Pouillet has shown, that the conversion of pure water into vapour does not produce electricity, but that vapour rising from solutions of salts and acids, however weak, gives evident signs of it, varying in kind, with the nature of the substance dissolved. Thus, from alkaline solutions, the vapour rises with signs of negative electricity; from saline or acid solutions, the vapour carries up a charge of positive electricity. As evaporation therefore is so abundant and constant at the surface of the earth, and as all natural collections of water, the ocean, lakes, rivers, and the humid soil, contain foreign ingredients, it may be supposed that evaporation, especially from the surface of the sea, is the most influential source of atmospheric electricity.

IV. While masses of visible vapour, or clouds, are good conductors of electricity, they are yet capable of electrical accumulation, because capable of being insulated, the air in proportion to its dryness being one of the most complete non-conductors known. M. Peltier, from observations and experiments made at Paris, has drawn the conclusion, that all gray and slate-coloured clouds are charged with negative, and that all the white, rose, or orange-coloured clouds are charged with positive electricity. If two clouds in this state approach within a certain distance, the effect is an accumulation of their respective electricities on the sides that are nearest to each other. When the accumulation becomes intense, the resistance of the intervening and insulating atmosphere is overcome, and an interchange takes place. There is a flash and detonation caused by the union of the two electric forces, or thunder and lightning. The same interchange frequently takes place between a cloud and the earth, with the same phenomena.

When the interchange is between two clouds, the electric spark goes from one to the other, probably leaving both bodies at once. Kaemtz speaks of having several times remarked, in two clouds of the same height, that two flashes of lightning have left each of them, and united in the middle of the interval that separated them.

When the interchange is between a cloud and the earth, the lightning shoots upwards and downwards, though this may not be perceptible owing to its extreme velocity. The ancient inhabitants of Etruria are said to have made the distinction of ascending and descending thunder.

V. Discharges of lightning of three kinds are discriminated by Arago, zigzag, sheet, and globular.

1. Zigzag lightnings, usually called forked, sharply defined on their edges, describe zigzags in space, and frequently bifurcate or trifurcate at their extremity, even ramifying into several divisions, though always proceeding from a single point. Thus on the 3rd of June, 1765, the lightning penetrated at the same instant, by four distant points, Pembroke College, Oxford; and in April, 1718, twenty-four churches were struck in the neighbourhood of St. Pol de Léon, while only three claps of thunder were heard. The zigzag course of the lightning, and its bifurcations, are probably caused by the unequal conductibility of the air.

2. Sheet lightnings, the most common form, are expanded flashes opening up at once, and illuminating whole clouds, so as distinctly to show their entire outline.

3. Globular lightnings, or balls of fire, have a slower motion, and are visible a few seconds. Many examples are on record. Mr. Chalmers states, that on November 4th, 1749, while on board the ship *Montague*, he observed a large ball of blue fire rolling along on the surface of the water, as large as a mill-stone, at about three miles distance; and before they could raise the main tack, the ball had reached within forty yards of the main chains, when it rose perpendicularly with a fearful explosion, and shattered the main-topmast to pieces. Ball lightnings, a subject of difficulty, are considered by Sir W. Snow Harris, as a constant renewal of discharges, instead of an intermittent action, moving onward with the cloud which carries the discharge.

VI. The lightning of the first two classes does not last for more than $\frac{1}{1000}$th of a second; but a less duration in passing than the one millionth part of a second is attributed to the light of electricity of high tension. In comparison with this

velocity, the most rapid artificial motion that can be produced, appears repose. This has been exemplified by Professor Wheatstone in a very beautiful experiment.

A wheel made to revolve with such celerity as to render its spokes invisible, is seen for an instant with all its spokes distinct, as if at rest, when illuminated by a flash of lightning, because the flash has come and gone before the wheel has had time to make a perceptible advance.

VII. The colour of lightning is variously orange, white, and blue, verging to violet. Its hue appears to depend on the intensity of electricity, and height in the atmosphere.

The more electricity there is passing through the air in a given time, the whiter and more dazzling is the light.

Violet and blue-coloured lightnings are observed to be discharged from storm-clouds high in the atmosphere, where the air is rarefied; and analogously, the electric spark made to pass through the receiver of an air-pump, exhibits a blue or violet light in proportion as the vacuum is complete.

VIII. Lightning in its course follows the best conductors, attaching itself principally to metals, and after metals to damp substances; but inferior conductors may be chosen which present to the fluid the most direct route to the earth. Hence objects raised above the surface, whether good or bad conductors, are peculiarly exposed to the stroke of lightning, as church-steeples, houses, trees, especially solitary ones, the masts of ships, animals in the midst of a plain, and men on high points. Other circumstances being equal, there is of course greater safety on a non-conducting than on a good conducting surface.

The loss of life through lightning, which seems to be occasioned by the shock given to the nervous system, may be locally small, but the aggregate of victims in many countries in a few years is great. Volney states, that in 1797, in little more than two months, twenty persons were struck, and seventeen fatally, in the United States. In 1819, twenty persons were killed in France.

On the night of July 4, 1832, M. Buchwalder, engaged in making geodesical experiments on the top of the Sentis, in the canton of Appenzell, at the height of 8200 feet, was in the very centre of a tremendous storm. He was struck, but not mortally, while his sole companion perished by his side.

IX. Lightning falling on combustible substances often produces ignition; and displays its irresistible force when encountering objects on its passage that are bad conductors, displacing walls, and removing large masses of stone to a distance. Vitreous globules found on the surface of rocks, and *fulgurites*, or fulminary tubes, occurring in beds of sand, mark its intense action.

Saussure, in ascending Mont Blanc, observed the vitrifying effect of lightning on the schistose rocks; and Humboldt on the trachytic porphyry of the Nevado de Toluca, in Mexico, at the height of 14,000 feet.

Fulgurites have been observed by Henzen in the sandy hillocks of Holstein; by Dr. Buckland and Mr. Greenough near Drigg, in Cumberland; by Mr. Darwin in sand-hills on the banks of the Plata river; and many other examples are given. They are tubes formed by the lightning striking into the loose sand, composed of its agglutinated particles, varying in length and diameter according to the energy of the electric fluid, contracted towards their lower extremity, and terminating in a point. That they are the effect of lightning has been ascertained by direct observation; and they may be artificially imitated by electrical experiments.

X. The position of the fulminary tubes in all instances hitherto examined deserves notice. They have been found to terminate in springs of water below the sand, or to be directed towards bodies which are good conductors of electricity. Hence it is not unlikely that repeated visits of the electric fluid to the same spot may be determined by the circumstances of the substrata.

A school-house in East Lothian has been struck three times by lightning, and similar repetitions have often been observed. St. Mark's tower at Venice is an example. It was injured in 1388, set on fire in 1417, and entirely consumed, being of wood, in 1489. Being rebuilt of stone, the lightning renewed its stroke in 1548, 1565, 1653, and 1745. Again it was damaged in 1761 and 1762; but in 1766 a lightning-conductor was put up, which has since protected it.

XI. Coincidently with Franklin's celebrated discovery of the electric nature of lightning, the means were suggested by him of protecting edifices from its ravages, by conductors in direct communication with the ground, presenting to the fluid an easier passage than that offered by the materials of a building.

For this purpose metallic rods are used, slightly projecting above an edifice, the object being not to invite the electricity, but to carry it off innocuously in case of an attack. The rod must be finely pointed, in perfect connection with the ground, free from interruption through its entire length, and of the same dimensions. Experience has shown that a proper lightning-conductor applied with the necessary precaution, is able to protect a circle having a diameter of about 20 yards.

The same means are employed with success to protect ships. Sir W. Snow Harris says, that out of 100 cases of ships belonging to the navy being struck, one half of them were struck on the mainmast, one quarter on the foremast, one-twentieth on the mizenmast, and one-hundredth on the bowsprit. One in six were set on fire in some part of the masts, sails, or rigging. In about one-half, some of the men were either killed or injured, to the number of 62 killed, and 114 wounded, exclusive of those instances in which all the crew perished through the vessels taking fire. But since lightning-conductors have been introduced into the navy, very few ships have been damaged, and none destroyed.

It has been conceived, that if a sufficient number of conductors were raised, the electricity of the atmosphere might be so far carried away as either to prevent thunder-storms altogether, or speedily dissipate them. Hence entire towns on the continent have been literally studded with *paratonneres*, thunder-rods. Upon the assumption also that electricity promoted congelation, and therefore caused hail, the foe of the agriculturist, whole fields and vineyards have been planted with *paragrêles*, tall wooden poles with straw ropes hanging loosely from the top to the ground. The inutility of such schemes for the purpose is apparent, when we consider that forest trees, blades of grass, spines of thorns, and all vegetable points, possess extraordinary powers of conduction, yet thunder-storms are just as common in the midst of luxuriant vegetation as in other districts.

XII. Thunder, the report of the electric discharge, heard at varying intervals after it, arises from the violent displacement of the air by the fluid in its passage, and its rush back into the partial vacuum created. The rolling of the sound is due partly to reverberation, and in part to the report from different points in the track of the lightning reaching the ear in succession.

The thunder follows the lightning because sound travels slower than the luminous sensation. The noise of thunder makes its deep impression rather by its volume than by its intensity. The loudest thunder can scarcely be heard at the distance of ten miles, and is less intense therefore than a piece of heavy artillery. The longest peals, as observed by De L'Isle, at Paris, lasted from thirty-five to forty-five seconds.

XIII. Lightning without thunder, usually termed heat-lightning, perfectly harmless, is often observed after sunset in summer, and during the night. By some it is attributed to the air being humid, and therefore favourably disposed for the conduction of the electricity, occasioning very frequent but weak discharges, so that no report is heard, and the flash is invisible by day because of its feebleness. Others regard these lights as reflections of the lightnings of storms situated below the horizon, no thunder being heard because of the distance.

At Demerara, heat-lightnings occur at the commencement of the rainy season, when storms are very common among the mountains in the interior.

Kaemtz relates, that in August, 1832, heat-lightning was very frequent at Geneva. On the 16th the subject was actively discussed in the *Société de Physique et d'Histoire Naturelle*. After the sitting, as though to test the opinions that had been advanced, heat-lightning illuminated the whole of the north horizon; and some days after, the newspapers were filled with accounts of the ravages of storms in Baden, Wurtemberg and Bavaria.

XIV. There is a class of interesting and quite harmless meteorological phenomena, due to the simple communication of electricity in a strong degree. It becomes visible in the form of pale-coloured flames, quivering on the extremities of bodies which are non-conductors, or insulated conductors, as the points of spears and other military weapons, the manes and tails of horses, the top-masts and yard-arms of ships. In showers of rain and snow, the drops have been observed to be luminous, owing to a strong charge of electricity in the air.

Mariner's Lights, or St. Elmo's Fire, often remarked by the ancients, is a phenomenon of this description, usually reckoned by sailors a fortunate omen. It was noticed during the voyages of Columbus and Magellan. M. Forbin thus describes its appearance, as observed by him in 1696:—"The sky was suddenly covered with thick clouds. Fearing a gale, I had all the sails reefed. There were more than thirty of St. Elmo's Fires on the ship: one of them occupied the vane of the mainmast, and was about five decimetres long (rather more than 19 inches). I sent a sailor to fetch it. When he was aloft, he heard a noise like that which is made when moist gunpowder is burned. I ordered him to take off the vane; he had scarcely executed this order when the fire quitted it, and placed itself at the apex of the mainmast, whence it could not possibly be removed."

On the east coast of the United States, in January, 1817, luminous appearances were seen by those who were out of doors. Their hats, gloves, and ears, the manes and tails of their horses, the bushes along the road side, and the trunks of trees, were all surrounded by a lively vacillating flame in different shapes, which emitted a slight noise like the simmering of water over a fire. At Freyburg, Professor Lampadius observed an intense development of electricity during a change of weather, snow and sleet falling. In the neighbourhood there was a strong phosphorescence at the extremities of the branches of the trees, which ceased when the branches were made to touch the ground by bending them down. The light was very distinct, of a bluish white colour, and the snow appeared luminous as it fell. In Iceland, the phenomenon, there called the Laptellitur, occurs in winter, during a strong wind and drifting snow, the whole sky appearing at night as if on fire.

The following is a recent instance of the same kind. On Sept. 25, 1840, an officer of the French army in Algeria observed that the arms of the men, when piled on the ground, exhibited nothing unusual; but when the men carried them, the points of the bayonets were strongly luminous. The drops of rain also that fell on their beards and mustachios, remained hanging from them in a state of phosphorescence. When the hair was wiped, the phenomenon ceased; but was renewed the moment any fresh drops fell on it.

XV. Electricity sympathises generally with light and heat in its geographical distribution, diminishing from the equator to the poles. Hence, it is within the tropics that thunder-storms are the most frequent, and at the same time the most violent, the lightning flashing with a breadth and intensity, and the thunder pealing with an awfulness of which no conception can be formed by the inhabitant of other regions. The coast-line of Peru, however, where it never thunders or lightens, is a remarkable exception. The comparative number of storms becomes

less, and their tone more subdued, as we recede from the tropics, so that in Europe, while there are about forty storms in the year in North Italy and Greece, Germany has only about twenty in the same interval, and Scandinavia not more than ten. In polar latitudes electrical explosions are still less frequent, and in some places entirely unknown. At the Faroe Islands thunder is seldom heard, and lightning is never known to do any injury. In Iceland, while lightning is not uncommon, especially in the neighbourhood of the volcanoes, thunder is rare, and was only heard once at Reikiavik in the interval between Sept. 21, 1833, and the end of August, 1835. It is stated by Gisecke, that during a residence for six years in Greenland, in lat. 70°, he only heard it thunder once.

In Europe, north of the Alps, the distribution of electrical explosions is analogous to that of rain. They occur principally in summer, except along the coast of Norway, where the greatest number falls in winter. Let 100 represent the total number of thunder-storms in a year, and the relative seasonal proportion will stand as follows:

	Winter.	Spring.	Summer.	Autumn.
West coast of Europe	8·9	17·7	52·5	20·9
Switzerland	0·4	20·6	69·0	10·0
Germany	1·4	24·4	66·0	8·2
Interior of Europe	0·0	15·7	79·3	5·0

Like the amount of rain, also, the number of storms decreases on passing into the interior of the continent:

	Annual Number of Storms.
West coast of Europe and Germany	about 20
Petersburg and Moscow	„ 17
Kasan	„ 9
Nertschinsk	„ 2
Irkutsk	„ 8

XVI. Magnetism, which extends its influence over every part of the earth's surface, was long supposed to be related to electricity, from the fact of lightning often rendering steel magnetic, and disturbing the magnetic needle, so that in thunder-storms a ship's compass has frequently been seriously injured. The two forces are now known to be identical, or rather but different forms under which the same power manifests itself; for according to Oersted's important discovery, electricity induces magnetism in the vicinity of the body which is conducting it, while Faraday's experiments have shown that free magnetism gives rise to electricity. The experiments of the latter go farther; for having succeeded in magnetising and electrifying a ray of light, and illuminating a magnetic line of force, there is reason to infer the elementary unity of these mightier agencies of nature, light and the magnetic and electric forces, as divergent energies having a common origin, functions of one and the same power.

The general phenomena of terrestrial magnetism are as follows:

1. A magnetic needle, freely suspended, as in the mariner's compass, everywhere on the surface of the earth and in the interior, takes a certain determinate position, more or less coinciding with the north and south polar points, but varying in different regions of the globe. The line of its direction is called the *magnetic meridian*; the divergence of the magnetic from the terrestrial meridian is called its *declination*, or *variation*; and knowing the variation, mariners are as well able to sail by the compass, as though the needle was in exact parallelism with the earth's axis, or pointed due north and south.

At present the variation of the magnetic needle at Greenwich from the meridian of Greenwich is 24° W. On travelling towards the west, the variation increases westerly, attains a maximum in the Atlantic Ocean, then decreases, till in North America there is no variation at all, the needle pointing exactly to the North Pole. Proceeding in the same direction, the variation becomes east, attains a maximum, diminishes, and becomes nothing in the east of Russia, the needle coinciding with the earth's axis. From thence to Greenwich the variation becomes westerly. Lines drawn through places where the needle points due north and south are termed *lines of no variation*.

The variation, however, in general, oscillates at the same place to a certain extent in a cycle of years. Thus at London in 1580, it was 11° 11′ E.; but in 1657, London was on the line of no variation, since which time it has been gradually increasing westerly. But there are places, as Spitzbergen, Jamaica, and the neighbouring islands, where no change in the variation has been perceptible. "The whole mass of West India property," says Sir John Herschel, "has been saved from the bottomless pit of endless litigation by the invariability of the magnetic declination in Jamaica and the surrounding archipelago during the whole of the last century; all surveys of property there having been conducted solely by the compass."

The variation also oscillates daily, probably under the influence of the course of the sun. The needle is in its mean position with us at about 10 A.M.; then it moves slowly westward and returns to its mean position by 10 P.M., moving slowly eastward, and returning during the next twelve hours.

The variation was first observed by Columbus, Sept. 13, 1493.

2. The magnetic needle, exactly poised and freely suspended, will not assume with us a position parallel to the horizon, but the extremity directed towards the north will incline downwards. This is called the *inclination* or *dip*. Exactly the opposite occurs in the southern hemisphere, where the extremity directed towards the south inclines or dips. But in equatorial regions there is no dip whatever, the needle assuming a perfectly horizontal position. A line connecting points where this is the case forms the *magnetic equator*. It does not coincide with the terrestrial equator, but deviates from it in some places as much as 15°, crossing it, however, at two opposite points, near the island of St. Thomas, on the west coast of Africa, and near little Gilbert's island, east of the Carolinas in the South Pacific. Receding from the magnetic equator, southwards and northwards, the dip of the needle increases. It makes an angle of 70° with the horizon in our latitude, the tendency to become vertical becoming stronger in higher latitudes. The dip of the needle was first observed by Robert Norman in 1576.

3. From the preceding facts, it is evident, that the earth acts as a great magnet, the poles of which determine the direction of the needle. Not being coincident with the geographical poles, and situated beneath the surface, we have hence the phenomena of the variation and the dip. In the northern hemisphere, where the north magnetic pole has the greatest effect, the corresponding extremity of the needle is attracted downwards to it, becoming vertical at the polar station. The effect of the south magnetic pole is similar in the southern hemisphere, while at the magnetic equator, where the influence of the two poles is equal, the dip is *nil*.

4. Commander, now Sir James Ross, attained to the north magnetic pole at 8 A.M. June 1, 1831, in lat 70° 5′ 17″, and long. 96° 46′ 45″ W., a spot on the west coast of Boothia, where the dip was 89° 59′ only one minute less than 90°, the vertical position, which would have precisely indicated the polar station. The same enterprising officer, Feb. 17, 1841, attained a point in the Antarctic Ocean where the dip was 88° 40′, making the nearest approach of any navigator to the south magnetic pole, being only 160 miles from it.

5. The intensity of the magnetic force varies in different parts of the earth, increasing generally from the equator to the poles. It is estimated in a similar manner to the force of gravity, by deviating the needle from its position in the magnetic meridian, and then allowing a free return to it, observing the oscillations made, and the interval that elapses before the position of rest is resumed. The oscillations will be more rapid, and the time less, in proportion to the intensity of the magnetic force. From experiments of this kind it is inferred, that there are two foci of greatest intensity in the northern hemisphere, the one in North America, and the other in Siberia, perhaps coinciding with the two points of greatest cold.

6. Lines of equal variation are called isogonial; lines of equal dip, isoclinial; and lines of equal intensity, isodynamical.

XVII. That meteoric display, occasionally seen in our heavens, the Aurora Borealis, or northern-light—the Aurora Australis, or southern-light, of the opposite hemisphere—is unquestionably of electro-magnetic origin, for it may be artificially imitated by passing a current of electricity through an exhausted receiver; violent disturbances of the magnetic needle precede and accompany its appearance; and light has been evolved by Faraday through magnetic power. In the course of the day, says Humboldt, "on which the lights are to appear, irregular horary movements of the magnetic needle usually indicate an interruption of equilibrium in the distribution of the terrestrial magnetism. When this disturbance has attained a great intensity, the equilibrium of the distribution is restored by a discharge, accompanied with an evolution of light. The splendid phenomenon of coloured northern-lights is the act of discharge, the conclusion of a magnetic storm; in the same way as in the electrical storm, lightning indicates the restoration of the disturbed equilibrium in the distribution of electricity."

XVIII. Auroral displays are very diversified, not only at different periods, but the same exhibition usually shifts through a succession of phases. Sometimes only flickering lights are seen streaming up from beneath the horizon towards the zenith; but in the more perfect and gorgeous appearances of high latitudes, there is generally a dark segment, sometimes black, or of a deep gray passing to violet, surmounted by a luminous arc of a brilliant white colour passing slightly to blue, and occasionally a second arc concentric with the first, their culminating points being in the magnetic meridian. The arc seldom remains stationary for more than a few minutes, but extends itself laterally, or rises and falls, or breaks in various places, or bends in convolutions like a ribbon exposed to the wind, while rays of almost every hue are incessantly darting from it towards the zenith, the "merry dancers" of the northern sky.

The northern lights have been seen by day, and in bright sunshine, owing to their intensity.

If the greater number of appearances fall in the winter half-year, one reason is, that the long nights favour the observation of them. In M. Mairan's list of recorded *auroræ boreales* down to the year 1754, the number given is 1441, of which 972 fall in the winter, and 469 in the summer months. They are thus distributed:

January	113	April	124	July	22	October	212
February	141	May	45	August	84	November	153
March	202	June	22	September	172	December	151

Other Tables support the inference to be deduced from this, that the number is very considerable in March, September, and October, or about the period of the equinoxes.

XIX. Auroral appearances, at least in certain districts, seem to observe a secular period, of the cause of which we know nothing, being frequent through a certain cycle, and becoming as rare through another.

XX. While the magnetic and electrical storms have one phenomenon in common—the evolution of light—the sphere of the latter is comparatively contracted, while that of the former embraces vast areas, extending sometimes to entire continents. This is indicated by the magnetic needle showing disturbance at the same time at widely remote points, and by isolated aurora being observed simultaneously at far distant stations.

The aurora borealis has been seen through a wide range of latitude, as far south as 45° in the southern hemisphere, while the aurora australis has been seen in England.

METEOROLOGY:—OPTICAL PHENOMENA.

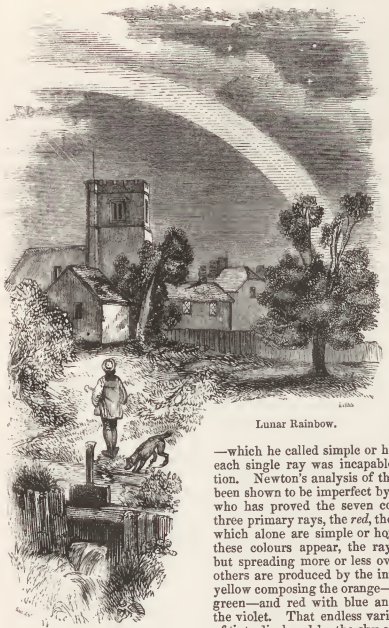
XXI. There is another respect in which the magnetic appears to differ from the electrical storm, in its discharges being conducted silently. It is true, that the Crees, Copper Indians, Esquimaux, and fur-traders of North America, and the inhabitants of the Shetlands, the Orkneys, and the Hebrides, maintain that when the aurora is intense, it is accompanied by a noise, variously compared to that of a fire agitated by the wind, and the crack of the electric spark. But with one or two exceptions, all scientific voyagers and travellers are unanimous in affirming, that when the aurora was most extensive and vivid, and when the most perfect calm and profound silence prevailed, they have failed to catch the faintest noise.

XXII. The northern lights, to us merely an object of curiosity and fascination, are of great practical utility to the natives of high latitudes, relieving their dreary winter night, and compensating for the long absence of solar illumination.

Aurora at Breuillepont, in Normandy, Oct. 19, 1726.

CHAPTER VIII.

OPTICAL PHENOMENA.



Lunar Rainbow.

I. Various and highly interesting effects result from the decomposition, refraction, and reflection of light in its passage through the atmosphere, in different conditions of the medium.

From Newton's analysis of the sunbeam admitted into a dark chamber through a hole in the window-shutter, and subjected to a prism, he inferred white light to be a compound of seven differently coloured rays—red, orange, yellow, green, blue, indigo, and violet—which he called simple or homogeneous, because each single ray was incapable of further separation. Newton's analysis of the solar spectrum has been shown to be imperfect by Sir David Brewster, who has proved the seven colours to result from three primary rays, the *red*, the *yellow*, and the *blue*, which alone are simple or homogeneous. Where these colours appear, the rays are concentrated; but spreading more or less over the spectrum, the others are produced by the intermixture—red and yellow composing the orange—blue and yellow, the green—and red with blue and a tinge of yellow, the violet. That endless variety and combination of tints displayed by the sky and the flowers of the fields, the rich hues of the autumnal woods, and the gorgeous plumage of tropical birds—in short, the colours of all objects, whether opaque bodies or transparent media arise from their varying capacity of absorbing or reflecting certain rays. The reflection of all the rays causes white, and the absorption of all black.

II. The cerulean tint of the clear sky, as previously explained, is the result of the blue rays being most abundantly reflected or scattered by the aërial particles, the greater paleness of the blue in passing from the zenith towards the horizon arising from the vesicular vapours in the lower strata of the atmosphere. The latter cause occasions the difference in tinge between the clear sky of ocean and of land. At sea the blue is paler than in the interior of continents, for there is a larger quantity of vesicular vapour in the atmosphere in the one place than the other. The Pacific, as seen from the summit of the Andes, exhibits a haziness, extending to the height of about 10,000 feet, covering as with a thin veil the surface of the ocean.

Sometimes, in fine weather, the zenithal sky appears of a paler blue than usual, and the sun is less brilliant. This arises from the vesicular vapours being very abundant, ascending to a great height in the atmosphere, without being sufficiently dense to appear as mists. But brilliant and prolonged twilights ensue, from the reflection of the solar rays, when the vapours are very elevated, while the lower regions of the air are transparent. In the months of August and September, 1831, the twilights were quite remarkable for duration and brightness at Madrid Genoa, Rome, Odessa, and many parts of Germany.

III. For some time about sunrise and sunset, on serene days, the predominant colour of the sky in the neighbourhood of the ascending and descending orb is very commonly yellow or red, though all intermediate tints between the lightest orange and the deepest purple are often exhibited. The solar beams having then the most considerable portion of the atmosphere to traverse in order to reach us, most of the blue rays are lost by absorption and reflection on their passage, while the red and yellow, which have the greatest momentum, variously modified by reflected light and by peculiar atmospheric conditions, are transmitted. Hence the sun, as seen from a diving-bell at some depth under water, appears a fiery globe, the one class of rays piercing the superincumbent fluid, the others being absorbed by it, or reflected from its surface. The fiery hue of the sky opposite to the setting sun, is caused by the red rays reaching that region being sent back by reflection to the eye of the observer. The rose-tint which frequently appears on the snowy summits of the Alps, a short time after sunset, is occasioned in a similar manner.

It is after all difficult to account for the variegated hues of morn and eve. To the preceding explanation, we may add, the influence of the vapour of water in the air,

METEOROLOGY:—SOLAR AND LUNAR RAINBOWS.

changeable in its amount and condition. Müller remarks, that when a column of steam rises from the safety-valve of a steam-engine, as, for instance, of a locomotive, the sun seen through the steam appears of a deep red; some feet above the safety-valve, at which the steam is escaping, its colour, by transmitted light, has a deep orange tint; at a greater distance, where the vapour is more perfectly condensed, the phenomenon entirely disappears. Thus, while aqueous vapour in a perfectly gaseous state is quite transparent and colourless, in the process of change to vesicular vapour, it is variously coloured red and orange, by freely admitting the passage of the red and yellow rays. Hence golden, rosy, purple, and fiery hues, may be determined by the presence of vapour in differing stages of condensation, and also in differing quantities, as we know that colour transmitted by a coloured glass often changes with the increase of its thickness.

Aqueous vapour perfectly condensed into vesicles, is transparent and colourless in thin layers; and hence the white fleecy appearance of thin clouds. But a moderately thick volume is impenetrable to the sun's rays, and casts a shadow like a solid body.

IV. As a certain portion of light is lost by absorption, and in other ways, in traversing even the most transparent media, the stars shine with greater lustre as seen from the summits of high mountains, than when beheld from a lower level, through an increased volume of the atmosphere. A number also come into view at great heights, which are not visible from the plains. They likewise scintillate less, as the cause of the phenomenon, the mixture of strata of air unequally heated producing unequal refraction, has less scope in proportion to the thinness of the atmospheric stratum.

The scintillation of the stars is the greatest towards the horizon: the least towards the zenith. It has been observed to occur with marked intensity on clear and very cold nights; also with a sky alternately cloudless and overcast; and during violent winds.

A communication from Professor Necker in the *Comptes Rendus*, 1841, states, that in the lower and eastern parts of Scotland, the fixed stars, even of the first magnitude, never twinkle, or only in a very slight degree. It is also remarked, upon the authority of Professor Forbes, that near Edinburgh, no scintillation is observed, unless when an aurora borealis prevails. "At Skye, on the contrary," he says, "all the fixed stars sparkle and scintillate as brightly as during the beautiful evenings of France and Switzerland. It is the same in the other Hebrides, in the Orkneys, Shetland, the whole of the northern coast of Scotland, and in the high regions of the Highlands. Now, it is to be remarked, that in none of these places are there any large towns, scarcely even burghs or large villages, and no manufactories of large extent which burn coal; the thinly-scattered population of these solitary regions use no other fuel but turf or wood, the very light smoke of which is soon dissipated without obscuring the atmosphere. Therefore the sky is as pure as in any part of continental Europe." The Professor attributes the non-appearance of scintillation in the other districts to the want of clearness in the air, owing to the dense coal-smoke of the large towns, villages, and manufactories, dispersed by the winds. But what influence the aurora borealis can have in re-establishing the scintillation does not appear.

V. When vapour has been condensed into fluid drops of water, and the spectator has his face to the showery cloud, with the sun shining at his back, he sees the glorious vision of the rainbow, a phenomenon due to the action of the rain-drops upon light. A pencil of light, on entering a rain-drop, undergoes refraction; and consisting of differently coloured rays possessed of different degrees of refrangibility, it emerges, after being reflected at the posterior wall of the drop, dissected into its primitive colours. Thus, from the action of the aqueous globule upon the luminous pencil, arises the coloured bow projected on the cloud, displaying the tints of the prismatic spectrum, the image being preserved constant and entire while its conditions co-exist, the continuance of the rain and the incident sunbeams.

Rainbow.

Lunar rainbows appear under the same circumstances as the solar, but are of rarer occurrence, because of the comparative feebleness of the lunar light. The more intense the light, the more vivid and distinct the colours of the bow, and *vicé versâ*. Hence lunar rainbows, while sometimes faintly showing the prismatic tints, are more generally only white or yellowish arcs.

In a letter dated Collingwood, November 13, 1848, addressed to the *Athenæum*, Sir John Herschel describes a very perfect lunar rainbow, witnessed for the first time, as follows: "The moon was near the eastern horizon, shining brilliantly through a considerable clear opening in the otherwise generally and densely clouded sky. A light, drizzling, and very uniform rain was falling, with a gentle wind from the NE. The arch, very nearly a semicircle, was perfect in every part—apparently much better defined and somewhat narrower than the solar rainbow, (circumstances easily accounted for.) Its span also appeared somewhat less, which of course was only an illusion. Though much brighter than I could have expected a lunar rainbow to appear, (the effect no doubt of the very dark background of cloud against which it was projected,) it exhibited scarcely any colour: barely enough to assure the spectators that the order of colour was as in the solar bow—a faint ruddy tinge being sensible on the outer, and a still fainter bluish hue on the inner side. When first seen it was perfect, and continued so for six or eight minutes, when clouds obscuring the moon put an end to it. I will only add, that the impression produced by the spectacle was of that peculiar, solemn, and unearthly kind, which, once experienced, remains ever after ineffaceable."

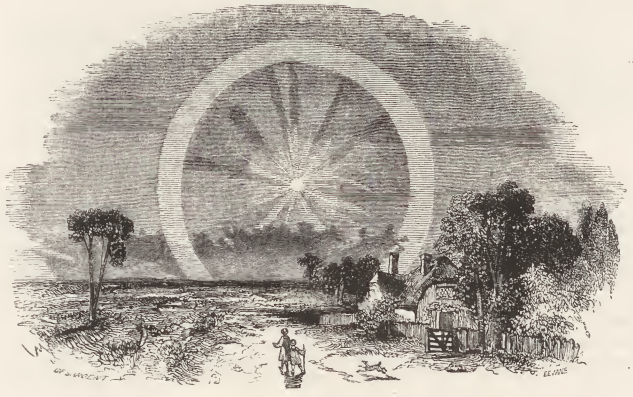
The rainbow forms the base of a cone, whose vertex is the eye, and whose axis coincides with a straight line passing through the eye and the sun. On a rain-cloud of small extent, only a portion of the bow can be projected, but it is sometimes seen continued along the blue sky, when the air contains a considerable amount of unaggregated vesicular vapour. When the sun is at the horizon, the bow forms a perfect semicircle to an observer on a plain; and more than a semicircle may be seen from an isolated elevation. The greater the altitude of the sun, the lower below the horizon is the centre of the bow, and consequently the smaller is the portion of the arc that is visible. When the sun's height is above 45°, no rainbow can be seen from a site at the sea level, because then its summit coincides with the horizon, and the entire arc falls below it. Hence, in our latitude, there is no rainbow visible towards the middle of the day in summer.

When the rain is copious, and the sun is brightly shining, a second bow appears exterior to the first, and concentric with it, but fainter, and with the order of the colours inverted. The lower edge of the primary or interior bow is violet, and the upper red; on the contrary, the lower edge of the secondary or exterior bow is red, and the upper violet. The secondary bow is produced by rays which have undergone a second interior reflection in the rain-drops, and is therefore fainter than the primary arch, because light is enfeebled by every reflection. Ternary and quaternary rainbows are spoken of, produced by a triple and quadruple reflection, but they are so exceedingly faint as not to be discernible.

METEOROLOGY:—THE PHENOMENA OF THE MIRAGE.

A coloured bow, similar to that which is produced by rain, may be observed under similar circumstances in the spray of a cataract, the shower of an artificial fountain, the dew upon the grass, and the mists that lie upon low grounds.

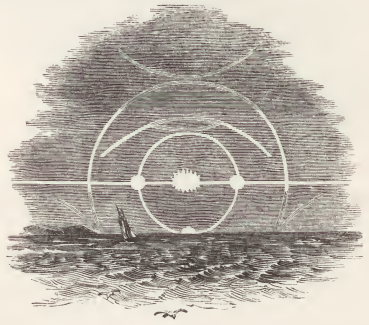
VI. Coloured circles of varying diameter are occasionally seen surrounding the sun and moon when the sky is invested with light clouds. These rings are designated by some *halos;* by others, *coronæ*. They are far more frequently observed around the moon, but this is simply owing to the sun's light being generally too dazzling to admit us to distinguish colours near his disc. If we study the solar image reflected in still water, or use a blackened mirror, and thus reduce the brilliancy of the sun's rays, then solar halos are observed, in that condition of the sky above described. They are occasioned by the inflection of light by the globules of visible vapour, or that property of the rays to bend and divide as they pass near the borders, ridges, and angles of surfaces. When halos are seen closely encircling the luminous body, and well defined, it is because the atmosphere is surcharged with humidity, large globules having been formed; and hence there is truth in the popular remark, that a dense halo portends rain. Frequently, with us, and always in high latitudes, icy particles take the place of vesicular vapours, in the production of halos.



Parhelia.

If we take a glass-plate upon which lycopodium seed has been strewed, and look at the flame of a taper through it, we perceive a glory or coloured circle surrounding the flame. The phenomenon answers to the halo, the minute particles of seed taking the place of the vesicular vapours in its production.

VII. Luminous circles, arcs, and horizontal bands of light, with mock-suns, *parhelia*, and mock-moons, *paraselenæ*, in the neighbourhood of the true orbs, are rare meteorological spectacles in our climate, but very common in the arctic regions, where snowy spiculæ, or minute crystals of ice float abundantly in the air, the angular forms of the crystals determining the rays of light in different regular directions, and originating the visual variety.



Parhelia.

Our old chronicles speak of these appearances. Whiston witnessed an example of parhelia in Rutlandshire, Oct. 22, 1721; and Dr. Trail, of paraselenæ, at Liverpool, on the evening of March 30, 1830. But they peculiarly belong to higher latitudes, and form there very gorgeous spectacles. The Icelandic annalists state, that in the severe winter of 1615, the sun, when seen, was always accompanied by two, four, five, and even nine of these illusions. Captain Parry describes and gives a drawing of a remarkable example, represented in the cut, which continued from noon until six o'clock in the evening, during his winter sojourn at Melville Island.

VIII. Illusions with reference to terrestrial objects are due to extraordinary reflection and refraction, caused by peculiar conditions of the air as to density. The *mirage*, the delusive appearance of water, common in the plains of Asia and Africa, on the verge of the horizon, is a well-known instance. In Egypt, the general aspect of the country is that of a plain, with gentle eminences on which the villages are seated. When the weather is calm, and the ground is highly heated, the landscape at a distance assumes the appearance of a pure transparent lake. The villages seem built on islands, their respective objects, houses and trees, are vividly reflected as if in water, and multiplied enlarged images of them are produced. So perfect is the representation, that experienced travellers, oppressed with heat and thirst, have accepted it as a reality, to find their hopes of speedy refreshment disappointed. This was the case with the French army during the celebrated campaign in Egypt.

> "Still the same burning sun! no cloud in heaven!
> The hot air quivers, and the sultry mist
> Floats o'er the desert, with a show
> Of distant waters mocking their distress."

The phenomena of the mirage, as above described, depend upon the earth being highly heated and the resulting evaporation. But the temperature of the air rapidly diminishes from the surface of the ground. Hence there are striking diversities in the density of the lower strata, and the rays of light are unequally refracted and reflected at the surfaces of strata of different densities.

Serab is the Arabic term for what we after the French call mirage. It occurs as a common emblem of deceit in oriental writings. The Koran says: "The actions of the unbelievers are like the *serab* of the plain: he who is thirsty takes it for water, and finds it to be nothing."

METEOROLOGY:—THE FATA MORGANA.

Mirage of the Desert.

IX. A singular spectacle is occasionally though but rarely exhibited in the narrow strait between Messina and Reggio. A variety of images, men, houses, cattle, rocks, and trees, are seen pictured on the surface of the water, and in the air immediately over it. Multiplied images of the same object sometimes occur, or two images, one in a natural, and the other in an inverted position; and they have been observed to be fringed with red, green, blue, and other prismatic colours. The scenery in this novel panorama is known by accurate observation to be derived from objects on the shore of Reggio. This exhibition is called by the Sicilians *fata morgana*, a title of uncertain derivation, but supposed to refer to a vulgar presumption of the spectacle being called into existence by fairy art or an enchanter's wand.

The *fata morgana* is a rarity, and appears to vary in its details. The physical circumstances under which it occurs, as to the temperature and humidity of the atmosphere, have not been carefully noted. It has been remarked, that the mountains on both sides of the strait nearly inclose a portion of quiescent or stagnant air, the temperature of which near the surface of the water is therefore easily raised above that of the surrounding objects. The differential refraction and reflection of the rays of light through media of different densities, is quite equal to explain the whole appearance, according to the laws of optics. Dr. Wollaston has shown, by the very simple experiment of looking at a distant object along a red-hot poker, that two images are seen, one direct and another inverted, owing to the change induced by the heat in the density of the adjacent air. If the atmosphere is in that condition adapted to form the iris, or hazy, the colours with which the images are said to be fringed are explained by the refraction of light through the small globules of vapour; and the same tints would equally accompany any real object, as a ship, under the same circumstances.

Fata Morgana at Reggio.

X. The apparitions in the air, which were once regarded as real supernatural appearances, take their rise from terrestrial objects, natural, or more frequently enlarged and distorted images of them being formed by peculiar reflection. The vision of troops of horses and armies marching and counter-marching in cloud-land, has sprung from some animals pasturing on an opposite height, or travellers quietly pursuing their journey.

Dr. Buchan relates, that while on the cliff near Brighton, with a companion, watching the sun rise, Nov. 18, 1804, he saw, just as the solar disc emerged above the surface of the water, the face of the cliff represented precisely opposite to him, with a neighbouring windmill, his own figure and that of his friend, all faithfully depicted at some height above the sea. The appearance lasted about ten minutes, till the sun had risen nearly his own diameter above the waves. The whole seemed then to be elevated into the air, and successively vanished. There was a dense fog upon the water at the time. The rays of the sun fell upon the cliff at an incidence of 73° from the vertical.

As two travellers were standing on the summit of Ben Lomond, Aug. 19, 1820, watching the sun set in the west, the attention of one of the party was arrested by the appearance of two gigantic figures pictured on a cloud in the east, apparently standing on an enormous pedestal. He pointed out the phenomenon to his companion, and immediately one of the figures was observed to strike the other on the shoulder, and pout towards them. They waved their hats and umbrellas, and the shadowy figures made a similar movement, faithfully imitating every gesticulation. The spectacle continued about a quarter of an hour.

The spectre of the Brocken, one of the Harz Mountains—the colossal figure of a man observed to walk the ridge at sunrise—is an analogous example.

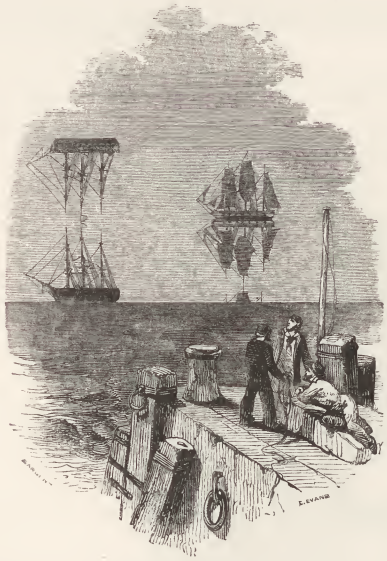
METEOROLOGY:—EFFECTS OF THE REFRACTION OF LIGHT.

XI. As owing to the refraction of light in the ordinary state of the atmosphere, the sun and moon appear above the horizon when actually below it, and the stars shine out from a greater elevation than what belongs to them, so terrestrial objects undergo an analogous deviation from the same cause, a fact of importance to be attended to in the measurement of mountains. But in atmospheric conditions favourable to extraordinary refraction, and when it takes place laterally and vertically, the visual circle of the spectator is singularly enlarged, and objects are magnified as if seen through a telescope. Mountains unseen before are brought within the range of visibility, and low coasts assume a bold and precipitous outline. Owing to a sudden change in the density of the air, the chain of the Himalaya has been transiently beheld from a point in the plains of Bengal, from which it had never been seen before. On July 26, 1798, the coast of France from Calais to near Dieppe was distinctly visible from the beach at Hastings, and appeared to be only a few miles off, though the nearest points are from forty to fifty, and are not discernible ordinarily from the low situation even with the aid of the best glasses.

In high latitudes, it is very common for extraordinary and unequal refraction to play "high fantastic tricks" with terrestrial objects. They generally occur on the evenings of clear days, and are most frequent on the approach or commencement of easterly winds. The most usual effect is an increase in the vertical dimensions of the objects affected, so that low coasts appear elevated, what seamen call *looming*, and sites below the horizon are brought into view. The Icelanders, who are familiar with this effect of atmospherical refraction, call it *upphillingar*, and regard it as a presage of good weather.

It is an old tradition, that Hvidsærk, a mountain in Greenland, and Sneefields, in Iceland, have both been visible at the same time from the middle of the intervening strait, which at the nearest point is about 300 miles wide. Though treated as a fable, it may be strictly true, owing to the effects of refraction. The last named mountain, Sneefields, though it is not seen under ordinary circumstances for more than 80 miles, has yet been often visible from the sea beyond the Westmanna Isles, a distance of more than 140 miles; and Scoresby relates having seen a part of the Greenland coast of inferior height, Home's Foreland 3500 feet high, when 160 miles distant.

The following details respecting unequal refraction in northern regions, produced by the varying temperature and density of adjacent strata of air, are from Scoresby.



Refraction in the Polar Sea.

June 19, 1822, the sun was very hot, and the coast suddenly appeared to come fourteen or eighteen miles nearer: the different eminences were so raised that they were seen as easily from the deck of the ship as they were before from the foretop. The ice in the horizon assumed singular forms; the larger blocks seemed columns; icebergs and fields of ice, a chain of prismatic rocks; and in many places, the ice appeared to be in the air at some minutes above the horizon. Ships, that were in the neighbourhood assumed the most whimsical forms; in some, the mainsail seemed reduced to nothing, while the foresail appeared four times larger than it really is; the topsail appeared shortened. There were also other whimsical appearances. Above the topsails was seen a sail resembling top-gallant-sails loose from the bolt-rope; in others, the topsail seemed divided into two, inasmuch as the true sail was separated from its image by an interval. Above distant ships their own image was seen inverted and magnified; in some cases, it was very high above the ship, and then it was always smaller than the original. The image of a ship, that was itself below the horizon, was seen for several minutes; a ship was even surmounted by two ships, one in the right position, the other inverted. Some days later, "the most curious phenomenon," says Scoresby, "was to see the inverted and perfectly distinct image of a ship, that was below our horizon. We had observed similar appearances; but the peculiarity of this was the distinctness of the image, and the great distance of the ship it represented. Its outline was so well marked, that on looking at this image through one of Dollond's telescopes, I distinguished the details of the rigging, and of the hull of the vessel, I recognised it as being my father's ship; and when we compared our log-books, we saw that we were then thirty miles apart, namely, seventeen below the real horizon, and many beyond the limit of distinct vision."

XII. The fall of minute particles of earthy matters from the atmosphere, frequently observed where no simultaneous projection of volcanic ashes in any adjoining region has been known to occur, is readily explained. The materials have been swept from the land by the winds, or borne up by ascending currents determined by the heating of the earth's surface, and are returned again in showers after undergoing transport in various directions and to various distances. Where no occurrence of the kind has been noticed before, it excites astonishment, but in certain districts of the globe the phenomenon is annual. Thus, along the west coast of Africa, between Cape Badajor and Cape Verde, and thence to a considerable distance into the Atlantic, the air, from November to May, is literally loaded with fine sand-dust derived from the African deserts, giving it quite a misty appearance. Ships traversing this region have often had their sails, rigging, and decks covered with the finely pulverised substances. At Bombay also a shower of dust on one occasion fell on the decks of the vessels to the depth of an inch, supposed to have been blown from the deserts of Arabia.

The dust has often fallen on ships when several hundred, and even more than a thousand miles from the coast of Africa, and at points sixteen hundred miles distant in a north and south-west direction. It falls in such quantities as to dirty everything on board, injure astronomical instruments, affect the eyes, and vessels have run on shore owing to the obscurity of the atmosphere. From the direction of the wind whenever it has fallen, and from the season coinciding with the months during which the harmattan blows in Senegambia, it is certain that the sand-dust all comes from Africa. The following particulars have been given from the journal of the Prussian ship, *Princess Louisa:*

1839.	Lat.	Long.	Outward Voyage.	Distance from Land.
Jan. 14.	24° 20′ N.	26° 42′ W.	Sails rendered quite yellow by sand, which had probably been brought from the coast of Africa.	12°
— 15.	23° 05′	28° 18′	Sails still yellow: when we struck the sails we found the colour was produced by fine sand, which was thus loosened.	12°
1840.			Homeward Voyage.	
May 6.	10° 29′	32° 19′	We remarked a yellow appearance on the sails like that seen during our outward voyage.	17°
— 7.	12° 20′	34° 0′	The sails more yellow than they were yesterday.	18°
— 8.	14° 21′	35° 24′	Sails and ropes covered with yellow dust.	19°
— 9.	16° 44′	36° 37′	No increasing dust visible on the sails.	20°

The distances from land mentioned are analogous to that of the plains of North Germany from the African Sahara.

Mr. Darwin, when at the Cape de Verde islands, collected a little packet of this brown-coloured fine dust, which appeared to have been filtered from the wind by the gauze of the vane at the mast-head. It was forwarded to Professor Ehrenberg along with four other small samples obtained from a different quarter. He found the dust to consist in great part of infusoria with siliceous shields, and of the siliceous tissue of plants, ascertaining in the five packets no less than fifty-seven different organic forms!

XIII. Though not belonging strictly to the domains of meteorology, yet some notice may be taken of events once supposed to originate in the atmosphere. The relations current in the middle ages, and extant in the Chronicles of those times, respecting showers of sulphur and of blood having fallen in various parts of Europe, have no doubt sprung from the descent of volcanic ashes transported to a distance, or of vegetable pollen, as well as from a development of the microscopic fauna and flora which form the colouring matter of red snow. A yellowish dust, easily inflammable, occasionally observed on ponds in certain districts, supposed to be sulphur has been referred to the pollen of vegetable productions

predominant in the neighbourhood, pines, elders, birch, alders, lycopodium and several species of equisetum, swept off by the breeze, and precipitated with the rain.

1. Red snow.—In all the alpine districts of Europe, crimson and rose-coloured snow is common. Saussure observed it in abundance on Mount Brevern, in Switzerland; Ramond, on the Pyrenees; and Sommerfeldt, in Norway. In 1808 it was seen on the whole country about Cadone, Belluna, and Feltri, in Italy, and at the same time on the mountains of Brescio, Carinthia, and the Tyrol. In 1823, it occurred at various points along the whole chain of the Apennines. Mr. Darwin noticed it on crossing the Chilian Andes in 1835; and it has been repeatedly met with by northern adventurers, as Ross and Parry. In 1840, it was found in great abundance in the neighbourhood of the hotel of Neuchatelois, near the crystal grottoes, on the lower glacier of Grindelwald, Switzerland; at the extremity of the glacier of Oberaar; on the glacier of Finsteraar; on the plains of snow which border the west flank of Siedelhorn; and in numerous points of the lower glacier of the Aar. No one pretends to have ever witnessed the coloured snow fall. Its descent in the night has been the vulgar presumption. Examined by the microscope, the colouring substance is found to be partly vegetable and partly animal. Red granules are observed, which, according to M. Ch. Martins, are vegetables reduced to their simplest expression, namely, to a cell filled with liquid, in which a great number of infusoria circulate.

Showers of blood have been supposed to have fallen at places apart from snow. This was the popular opinion at Aix, in June 1608, when various points in the suburbs, and especially a churchyard, were observed to be covered with crimson-spots. But M. Peiresc gave at the time no doubt the true explanation of the circumstance, referring it to the coincident appearance of prodigious swarms of insects, which always discharge a substance in evolving from the pupa state, of a red colour in the case of butterflies, that of several kinds of moths being orange or whitish.

2. Green snow.—M. Ch. Martins, who twice accompanied the French expedition to Spitzbergen, observed at his landing, July 25, 1838, on traversing a field of snow, that while at the surface it was white, at an inch or so beneath it was green, as if it had been watered with a decoction of spinach. On another excursion, he observed the green snow at the surface. The Parisian Professor and his companions concluded generally, that the red and green granules of coloured snow are one and the same microscopic plant in different stages of development; that red is the colour of the primitive state, which afterwards becomes green under the influence of light and air; but these views require to be substantiated.

3. Black snow.—So the inhabitants of the Orkneys denominated a dark powder resembling lamp black, which fell in those islands, and the Shetlands, Oct. 20, 1755. There is little doubt of this being a volcanic product, transported by the winds, as a violent eruption of Kötlaegia, a mountain in the south of Iceland, commenced in that year, Oct. 17, and continued to Nov. 7. A similar fact has not received any explanation. On February 7, 1837, the remarkably pure Lock Erne, in Perthshire, was observed to be covered with a black scum, which lay in a thin stratum upon its surface. The black powder was not confined to the waters of the loch, but was found on the land, at the farm of Miggar, several miles from it. Professor Connel, upon analysing a portion of the water of Loch Erne, found the powder to be essentially carbonaceous with some siliceous admixtures; but was quite unable to offer an opinion respecting its origin in such a situation. It had evidently fallen in the atmosphere, been transported by it, and the query may be started, whether it may be linked with the earthquake shock which convulsed Palestine early in the preceding month, (January) destroyed Safet, rent the ground into fearful chasms around the lake of Tiberias, threw down the minarets of Damascus, and part of the walls of Acre, and was sensibly felt at Constantinople?

XIV. Fogs, remarkable for their drying properties, hence called Dry Fogs, as distinguished from ordinary damp mists, are at times observed, and have occasioned controversy respecting their cause. They spread as a haze over large districts, giving to nature "a dim and sickly eye," diffuse a peculiar odour, and exhibit a pale blue colour. Local dry fogs may be due to the combustion of peat, as suggested by Kaemtz. This transpires upon an extensive scale in midland Europe, where the peat-bogs are set fire to in very dry seasons in order to form cultivable land, and forests are accidentally ignited, occasioning terrible conflagrations. But it is impossible to account in this way for the fog of 1783, which extended over a large section of the northern hemisphere. It was first seen at Copenhagen, May 29th, and about the same time in England. The sun rose and set without his rays, even in a cloudless sky, and the moon high in heaven had the colour of heated brick. It appeared at Rochelle, on June 6th; at Dijon, on the 14th; everywhere in France, Germany, and Italy, between the 16th and 18th; at the St. Gothard, and at Buda, on the 23rd; at Moscow, on the 25th; in Syria towards the end of the month; and at the Altai mountains, on July the 1st. It reached also the north coast of Africa, and was noticed over a great part of North America. Very probably its production was connected, though in a way we cannot point out, with the natural convulsions of that remarkable year, when the greatest mass of volcanic matter, hitherto ascertained to be the product of an eruption, was ejected in Iceland, and the earthquakes occurred by which Calabria and Sicily were desolated.

The best account of the fog of 1783 is given by M. Arago in his "Scientific Notices of Comets," inserted in the French *Annuaire* for 1832, replying in the negative to the question, "Whether the Dry Fogs of 1783 and 1831, were occasioned by the tail of a Comet?"

XV. The wandering meteor called *Ignis fatuus*, and popularly, *Will-o'-the-wisp*, is peculiar to sites where processes of decomposition and putrefaction are going on. Though now somewhat rare with us, it is not so in various continental districts, appearing in battle-fields and marsh lands, with a flickering unsteady motion, a few feet above the ground, and speedily vanishing. It has been referred to the phosphuretted hydrogen emitted by putrefying animal remains, which inflames as soon as it is in contact with atmospheric air; and to the light carburetted hydrogen obtained from decomposing vegetable substances ignited by an electric spark; but though inflammable action has in some cases been evidenced, the meteor is perhaps more generally only a faint phosphorescence, not burning as a flame, arising from hydrogen gas containing phosphorus.

Ignis Fatuus.

ORGANIC LIFE.

CHAPTER I.

BOTANICAL GEOGRAPHY.

WHEN treating of the geographical distribution of vegetables, we have to mark the general arrangements indicated, and the agencies that have evidently operated in promoting the diffusion of floral tribes. Vegetation occurs over the whole globe, therefore, under the most opposite conditions. Plants flourish in the bosom of the ocean as well as on land, under the extremes of cold and heat in polar and equatorial regions, on the hardest rocks and the soft alluvium of the plains, amidst the perpetual snow of lofty mountains, and in springs at the temperature of boiling water, in situations never penetrated by the solar rays, as the dark vaults of caverns, and the walls of mines, as well as freely exposed to the influences of light and air. But these diverse circumstances have different species and genera. There is only one state which seems fatal to the existence of vegetable life—the entire absence of humidity.

By species we understand so many individuals as intimately resemble each other in appearance and properties, and agree in all their permanent characters, which are founded in the immutable laws of creation. An established species may frequently exhibit new varieties, depending upon local and accidental causes, but these are imperfectly, or for a limited time, if at all, perpetuated.

A genus comprises one or more species similar to each other, but essentially differing in formation, nature, and in many adventitious qualities from other plants. A tribe, family, group, or order, comprises several genera.

II. The known number of species in the vegetable kingdom has been gradually enlarged by the progress of maritime and inland discovery; but owing to great districts of the globe not having yet been explored by the botanist, the interior of Africa and Australia, with sections of America, Asia, and Oceanica, it is impossible to state the exact amount. The successive augmentation of the catalogue appears from the numbers below:

	Species.		Species.
Theophrastus	500	Persoon	27,000
Pliny	1000	Humboldt and Brown	38,000
Greek, Roman, and Arabian botanists	1400	De Candolle	56,000
		Lindley	86,000
Bauhin	6000	Hinds	89,000
Linnæus	8800		

III. Vegetable forms are divided into three great classes which differ materially in their structure:—1. Cryptogamous plants—those which have no flowers properly so called, mosses, lichens, fungi, and ferns; as distinguished from those which are phænogamous, or flower-bearing, to which the two following classes belong. 2. Endogenous plants, which have stems increasing from within, also called Monocotyledons, from having only one seed-lobe, as the numerous grasses, lilies, and the palm family. 3. Exogenous plants, which have stems growing by additions from without, also called Dicotyledons, from the seed consisting of two lobes, the most perfect, beautiful, and numerous class, embracing the forest trees, most flowering shrubs and herbs.

The exogens furnish examples of gigantic size, and great longevity. In South America, on the banks of the Atabapo, Humboldt measured a *bombax caiba* more than 120 feet high, and 15 in diameter; and near Cumana, he found the *Zamang del Guayra*, a species of mimosa, the pendant branches of the hemispherical head having a circumference of upwards of 600 feet. The *Adansonia*, or boabad of Senegal, though attaining no great height, rarely more than 50 feet, has a trunk with a diameter sometimes amounting to 34 feet; while the *Pinus Lambertiana*, growing singly on the plains west of the Rocky Mountains, has been found 250 feet high, 60 feet in circumference at the base, 44 feet in girth at the height of 190 feet, yielding cones 11 inches round and 16 long. The *Ficus Indicus*, or banian tree, sending out shoots from its horizontal branches, which reaching the ground take root, and form new stems, till a single tree multiplies almost to a forest, has been observed covering an area of 1700 square yards.

The Banian Tree.

From the number of concentric zones observed in a transverse section of the stems, De Candolle advances proof of the following ages:

Elm	335 years	Oriental Plane, 720 years and upwards	
Cypress	about 350 „	Cedar of Lebanon, about 800	
Cheirostemon	„ 400 „	Oak	810; 1080; 1500
Ivy	450 „	Lime	1076; 1147
Larch	576 „	Yew	1214; 1458; 2588; 2880
Orange	630 „	Taxodium	4000 to 6000
Olive	700 „	Boabab	5150.

Admitting, with Professor Henslow, that De Candolle overrated the ages of these trees one-third, they are examples of extraordinary longevity. Yew trees upwards of 700 years old remain at Fountains Abbey, Yorkshire, as there is historic evidence of their existence in the year 1133. But a yew in the churchyard of Darley-in-the-Dale, Derbyshire, is considered by Mr. Bowman as 2006 years old.

IV. The cryptogamous plants afford the most numerous examples of wide diffusion. A lichen indigenous in Cornwall, *sticta aurata*, is also a native of the West India islands, Brazil, St. Helena, and the Cape of Good Hope; while

ORGANIC LIFE:—VEGETATION OF THE TROPICS.

38 lichens and 28 mosses are common to Great Britain and Australia, though the general vegetation of the two districts is remarkably discordant. Some species of endogenous plants are also widely distributed, the *phleum alpinum* of Switzerland occurring without the slightest difference at the Strait of Magellan, and the quaking grasses of Europe in the interior of Southern Africa. But only in very few instances are the same species of exogenous plants met with in regions far apart from each other; and generally speaking, in passing from one country to another, we encounter a new flora; for if the same genera occur, the species are not identical, while in districts widely separated the genera are different.

The cryptogamic plants, mosses, lichens, ferns, and fungi, are to the whole mass of phænogamic vegetation, in the following proportions in different districts: Equatorial latitudes, 0° to 10°, on the plains, $\frac{1}{20}$, on the mountains, $\frac{1}{4}$; mean latitudes, 45° to 52°, $\frac{1}{3}$; high latitudes, 67° to 70°, proportion about equal. Thus the proportion of flowerless vegetation to the flowering increases from the equator to the poles. But the family of ferns, *filices*, viewed singly, forms an exception to this law, decreasing as we depart from equinoctial countries, being $\frac{1}{10}$ in equatorial and $\frac{1}{70}$ in mean latitudes, and not found at all in the high latitudes of the new world.

Proportion which several families of plants bear in different latitudes to the entire mass of vegetation, excluding the cryptogamia, derived from Humboldt. The latitudinal zones, as above defined, are denoted by E equatorial, M mean, H high.

I. ENDOGENOUS.

1. *Junceæ*, a small tribe named from its type, the rush: $\frac{1}{1000}$ E; $\frac{1}{100}$ M; $\frac{1}{17}$ H.
2. *Cyperaceæ*, an extensive order to which the sedges belong: $\frac{1}{22}$ in the old and $\frac{1}{50}$ in the new world E; $\frac{1}{20}$ M; $\frac{1}{5}$ H.
3. *Gramineæ*, the most important of all vegetable tribes, comprehending the most valuable pasture and all the corn yielding plants, wheat, barley, oats, maize, rice, with the sugar-cane, &c.: $\frac{1}{14}$ E; $\frac{1}{12}$ M; $\frac{1}{10}$ H.

II. EXOGENOUS.

4. *Compositæ*, the largest known natural order of plants, named after their compound flowers, estimated at $\frac{1}{12}$th of the whole vegetable kingdom. The daisy, thistle, dandelion, lettuce, tansy, aster, artichoke, marigold, and dahlia, some of which assume quite an arborescent character in warm climates, are familiar examples: $\frac{1}{18}$ in the old and $\frac{1}{32}$ in the new world E; $\frac{1}{8}$ in the old and $\frac{1}{6}$ in the new world M; $\frac{1}{18}$ H.
5. *Leguminosæ*, plants the fruit of which is generally a legume, varying vastly in form and size, including the common bean and pea, the laburnum, and some of the stateliest members of the tropical forest, the mimosa, tamarind, and the trees yielding logwood, Brazil-wood, &c.: $\frac{1}{10}$ E; $\frac{1}{18}$ M; $\frac{1}{28}$ H.
6. *Euphorbiaceæ*, comprising the plants from which the resin called euphorbium, castor, croton, and other oils are derived, varying from minute herbs to trees of the largest size: $\frac{1}{32}$ E; $\frac{1}{80}$ M; $\frac{1}{1000}$ H.
7. *Labiatæ*, an extensive family of plants, generally herbaceous and never exceeding the size of small bushes, usually containing an aromatic or tonic volatile oil, as mint, thyme, sage, lavender, rosemary, horehound, &c.: $\frac{1}{10}$ E; $\frac{1}{40}$ in America and $\frac{1}{25}$ in Europe M; $\frac{1}{70}$ H.
8. *Malvaceæ*, the mallow tribe, generally herbaceous, a few species becoming trees in hot countries, remarkable for large and beautiful flowers: $\frac{1}{35}$ E; $\frac{1}{1000}$ M; $\frac{0}{0}$ H.
9. *Ericeæ*, an order in which the genus *erica*, heaths, is prominent, but including the rhododendron, azalea, arbutus, &c., forming perhaps the most beautiful tribe in the vegetable world: $\frac{1}{1800}$ E; $\frac{1}{1000}$ in Europe and $\frac{1}{70}$ in America M; $\frac{1}{25}$ H.
10. *Amentaceæ*, forest trees bearing flowers in *amenta* or catkins, as the birch, willow, hazel, poplar. chestnut, pine, elm, oak, &c.: $\frac{1}{600}$ E; $\frac{1}{15}$ in Europe and $\frac{1}{25}$ in America M; $\frac{1}{10}$ H.
11. *Umbelliferæ*, herbaceous plants the flowers of which are disposed in umbels, as the hemlock, carrot, caraway, coriander, &c.: $\frac{1}{1000}$ E; $\frac{1}{400}$ M; $\frac{1}{60}$ H.
12. *Cruciferæ*, an extensive order, comprehending the mustard, cress, turnip, cabbage, scurvy-grass, radish, and similar plants, which have a part of their inflorescence placed something like the arms of a Maltese Cross: $\frac{1}{8000}$ E; $\frac{1}{18}$ in Europe and $\frac{1}{60}$ in America M; $\frac{1}{24}$ H.

V. In equinoctial and tropical countries, where a sufficient supply of moisture combines with the influence of light and heat, vegetation appears in all its magnitude and glory. Its lower orders, mosses, fungi, and confervæ, are very rare. The ferns are arborescent. Reeds ascend to the height of a hundred feet, and rigid grasses rise to forty. The forests are composed of majestic leafy evergreen trees bearing brilliant blossoms, their colours finely contrasting, scarcely any two standing together being of the same species. Enormous creepers climb their trunks; parasitical orchidæ hang in festoons from branch to branch, and augment the floral decoration with scarlet, purple, blue, rose, and golden dyes. Of plants used by man for food, or as luxuries, or for medicinal purposes, occurring in this region, rice, bananas, dates, cocoa, cacao, bread-fruit, coffee, tea, sugar, vanilla, Peruvian bark, pepper, cinnamon, cloves, and nutmegs, are either characteristic of it as principally cultivated within its limits, or entirely confined to them.

1. Rice, (*Oryza-sativa,*) the chief food of perhaps a third of the human race, is cultivated beyond the tropics, but principally within them, only where there is a plentiful supply of water. It has never been found wild; its native country is unknown; but probably southern Asia.
2. Bananas, or plantains, (*Musa sapientum et paradisiaca,*) are cultivated in intertropical Asia, Africa, and America. The latter species occurs in Syria. The banana is not known in an uncultivated state. Its produce is enormous, estimated to be on the same space of ground to that of wheat, as 133 to 1, and to that of potatoes as 44 to 1.
3. Dates, (*Phœnix dactylifera,*) and cocoa, (*Cocos nucifera,*) belong to the family *Palmæ*. The palms, remarkable for their elegant forms and importance to man, contribute more than any other trees to impress upon the vegetation of tropical and equinoctial countries its peculiar physiognomy. The date palm is a native of northern Africa, and is so abundant between the Barbary states and the Sahara, that the district has been named Biledulgerid, the land of dates. As the desert is approached, the only objects that break the monotony of the landscape are the date palm, and the tent of the Arab. It accompanies the margin of the mighty desert in all its sinuosities from the shores of the Atlantic to the confines of Persia, and is the only vegetable affording subsistence to man that can grow in such an arid situation. The annual produce of an individual is from 150 to 260 lbs. weight of fruit. The cocoa palm furnishes annually about a hundred cocoa-nuts. It is spread throughout the torrid zone; but occurs most abundantly in the islands of the Indian archipelago. The family of palms is supposed to contain a thousand species, some of large size, forming extensive forests.
4. Cacao, (*Theobrama cacao,*) from the seeds of which chocolate is prepared, grows wild in central America, and is also extensively cultivated in Mexico, Guatimala, and on the coast of Cumana.
5. Bread-fruit tree, (*Artocarpus incisa,*) a native of the South Sea Islands and Indian archipelago, grows also in Southern Asia, and has been introduced into the tropical parts of America; but the fruit is not equal to the banana as an article of human food.
6. Coffee, (*Coffea Arabica.*) The bush has probably for its native region the Ethiopian Highlands, from whence it was taken in the fifteenth century to the Highlands of

A Palm Forest.

Yemen, the southern part of the Arabian peninsula. It has been introduced, and is now extensively cultivated in British India, Ceylon, Java, the Mauritius, Brazil, and the West Indies, but the quality is inferior, which makes the climate of the Mocha coffee district of importance, as peculiarly favourable to the plant. It grows there on hills described by Niebuhr as being soaked with rain every day from the beginning of June to the end of September, which is carefully collected for the purpose of irrigation during the dry season. Forskhäl gives the following temperatures in the district:

Beit el Fakih . .	March 16,	7 A.M..	76°	1 P.M.,	95°	10 P.M.,	81°
,,	,, 18,	,,	77	,,	95	,,	81
Hodeida	,, 18,	,,	72	,,	92¾	,,	78
Bulgosa, a village in the hills	,, 20,	,,	69½	,,	85½	,,	73

Coffee was first introduced into Venice in 1615; into England in 1652; and into France in 1658.

7. Tea, (*Thea Chinensis.*) The plant is indigenous in China, Japan, and Upper Assam. In the latter country, it has recently been found in a wild state, and is in process there of extensive cultivation. As the plant is hardy, its culture has very lately been attempted in the south of France, and apparently with complete success. A similar experiment on the burning plains of Algeria completely failed, all the plants being killed by the heat, notwithstanding every precaution. Tea was first introduced into Europe by the Dutch in 1666. The leaves of the coffee-plant have long been used as a substitute for tea by the lower-classes in Java and Sumatra; and recently, Professor Blume, of Leyden, exhibited samples of tea prepared from coffee-leaves, agreeing entirely in appearance, odour, and taste, with the genuine Chinese production.

8. Sugar-cane, (*Saccharum officinarum,*) a species of *Gramineæ*, occurs to some extent without the tropics, having been cultivated centuries ago in Europe, as at present scantily in the south of Spain. But it properly belongs to the torrid zone, and has for its principal districts, the southern United States, the West Indies, Venezuela, Brazil, the Mauritius, British India, China, the Sunda and Philippine Islands. The plant was found wild in several parts of America on the discovery of that continent, and occurs in a wild state on many of the islands of the Pacific.

9. Vanilla, (*Vanilla aromatica,*) the fruit of which forms the well-known aromatic, grows wild principally in Mexico.

10. Peruvian bark, (*Cinchona officinalis,*) a forest tree, of which there are several species, furnishing the valuable medicine so called. It is exclusively confined to South America, and grows chiefly on the Andes of Loxa and Venezuela.

11. Pepper, (*Piper nigrum,*) belongs exclusively to the Malabar coast, where it has been found wild, Sumatra, which produces the greatest quantity, Borneo, the Malay peninsula, and Siam. Other species of *Piperaceæ* occur in tropical America.

12. Cinnamon, (*Laurus Cinnamomum,*) a small tree yielding the aromatic bark, is found native only in the Island of Ceylon; but another species occurs in Cochin China.

13. Clove, (*Myrthus caryophyllus,*) an evergreen small tree, the dried flower-buds of which form the celebrated aromatic, grows naturally in the Moluccas, whence it has been conveyed to other tropical districts. The island of Amboyna, one of that group, is the principal seat of its cultivation. The lowest temperature there is 72°; the mean temperature of the year 82°.

14. Nutmeg (*Myristica mostacha,*) grows naturally in several islands of the eastern archipelago, but is principally cultivated in the Banda Isles.—See Botanical Map.

VI. Tropical families and forms successively vanish with an increase of distance from the equator, and new phases of vegetation mark the transition from hot to temperate climates. Vividly green meadows, abounding with tender herbs, replace the tall rigid grasses which form the impenetrable jungle; and instead of forests composed of towering evergreen trees, woods of the deciduous class appear, which cast their leaves in winter, and hybernate in the colder season, the oak, ash, elm, maple, beech, lime, alder, birch, and sycamore. The cultivation of the vine becomes characteristic, with the perfection of the cereal grasses, and a larger proportion of herbaceous annuals and cryptogamic plants.

The vine (*Vitis vinifera*) is less impatient of a cold winter than a cool summer. Hence its northern limit, which coincides with lat. 47° 30′ on the west coast of France, rises in the interior, where, though the winters are colder, the summers are warmer, to lat. 49°, cuts the Rhine at Coblentz in lat. 50° 20′, and ascends to 52° 31′ in Germany.

VII. Receding further from the equator, magnificent forests of the fir and pine tribe prevail, as in the central parts of Russia, on the southern shores of the Baltic, in Scandinavia, and North America. But some of the cereals are no longer cultivatable, and several timber-trees common to the temperate zone do not reach its northern limits. Gradually all ligneous vegetation disappears entirely as higher latitudes are approached, the woods having first dwindled to mere dwarfs in struggling with the elements, hostile to that state which nature destined them to assume. The limit of the forests is a sinuous line running along the extreme north of the old world; and extending from Hudson's Bay, lat. 60°, to the Mackenzie River, lat. 68°, and thence to Behring's Strait. The dwarf birch (*Betula nana*), a mere bush, is the last tree found on drawing near the eternal snow of the pole. At the island of Hammerfest, lat. 70° 40′, near the North Cape, it rises to about the height of a man, in sheltered hollows between the mountains, its lower branches trailing on the ground, affording a shelter to the ptarmigan. In the polar zone, some low flowering annuals, saxifrages, ranunculi, gentians, chickweeds, and others, flourish during the brief ardent summer; a few perennials also accommodate themselves to the rigorous climate by spreading laterally, never rising higher than four or five inches from the ground; till finally no development of vegetable life is met with, but lichens, and the microscopic forms that colour the snow.

In Europe, wheat ceases with a line connecting Inverness in Scotland, lat. 58°, Drontheim in Norway, lat. 64°, and Petersburgh in Russia, lat. 60° 15′. Oats reach a somewhat higher latitude. Barley and rye ascend to lat. 70°, but require a favourable aspect and season to produce a crop.

The northern limit of the growth of oak, lat. 61°, falls short of that of wheat. The oak makes a singular leap at the confines of Europe and Asia, (see Botanical Map,) disappearing towards the Ural Mountains. This is the case also with the wild-nut and apple. The oak and the wild-nut, however, reappear suddenly in Eastern Asia, on the banks of the Argoun and the Amour; and the apple occurs anew in the Aleutian Isles.

The following are the northern limits of several trees in Scandinavia:

Beech, *Fagus silvatica*	60°	0′	lat.
Hard Oak, *Quercus robur*	61	0	,,
Common Elm, *Ulmus campestris*	61	0	,,
Common Lime, *Tilia communis*	61	0	,,
Common Ash, *Fraxinus excelsior*	62	0	,,
Fruit trees	63	0	,,
Hazel, *Corylus avellana*	64	0	,,
Spruce Fir, *Abies excelsa*	67	40	,,
Service Tree, *Sorbus aucuparia*	70	0	,,
Scotch Fir, *Pinus silvestris*	70	0	,,
White Birch, *Betula alba*	70	40	,,
Dwarf Birch, *Betula nana*	71	0	,,

VIII. Thus distinct vegetable regions are observed on passing from south to north through different climatic zones, defined as to their limits by the isothermal curves, and not by the parallels of latitude. Similar changes of vegetation mark a perpendicular transit through varying climates. A succession of plants appear on the tropical mountains which rise above the snow line, corresponding to those which are encountered in mean and high latitudes. The higher we ascend, the more does the number of the phænogamic class diminish in proportion to the cryptogamic, till only members of the latter family are found, whose further progress upward is arrested by the everlasting snow. The last lichen met with by Saussure on Mont Blanc, *silene acaulis*, was also observed by M. Brevais in the neighbourhood of Bosekop, lat. 69° 58′, where it was vegetating on the seashore shaded by the last pines of Europe.

Isolated mountains display to the best advantage the effect of climatic change on vegetation.

I. Etna is divided into three great regions: *La Regione Culta*, or fertile region; *La Regione Sylvosa*, or woody region; *La Regione Deserta*, the bare or desert region. But each of these is susceptible of subdivisions, defined by the presence of certain families of plants, forming seven botanical zones.

1. The sub-tropical zone, which does not rise more than 100 feet above the level of the sea, is characterised by the palm, banana, Indian fig, sugar-cane, varieties of mimosa and acacia, which with us are only found in conservatories.

2. The hilly zone rises about 2000 feet, characterised by the orange, lemon, shaddock, maize, cotton, and grape plants.

3. The woody zone lies between the height of 2000 and 4000 feet, where the cork-tree flourishes, several kinds of oak, the maple, and enormous chestnuts.

4. The zone between the height of 4000 and 6000 feet is distinguished by the beech, Scotch fir, birch, and, among small plants, by clover, sandwort, chickweed, dock, and plantain.

5. The sub-alpine zone, between the elevation of 6000 and 7500 feet, produces the barberry, soap-wort, toad-flax, and juniper.

6. The zone between 7500 and 9000 feet, has almost all the plants of the preceding, with the fleshy and jagged groundsel.

7. The narrow zone between 9000 and 9200 feet, only produces a few lichens, beyond which there is complete sterility.

II. The Peak of Teneriffe exhibits five botanical districts, thus distinguished by Von Buch:

1. The Region of African forms, 0—1248 feet, comprising palms, bananas, the sugar-cane, various species of arborescent *Euphorbiæ*, *Mesembryanthema*, the *Dracæna*, and other plants, whose naked and tortuous trunks, succulent leaves, and bluish-green tints, are distinctive of the vegetation of Africa.

2. Region of Vines and Cereals, 1248—2748 feet, comprising also the olive, and the fruit-trees of Europe.

3. Region of Laurels, 2748—4350 feet, including lauri of four species, the wild olive, an oak, the iron-tree, the arbutus, and other evergreens. The ivy of the Canaries and various twining shrubs cover the trunks of the trees, and numerous species of fern occur, with beautiful flowering plants.

4. Region of the Pines, 2748—6270, characterised by a vast forest of trees resembling the Scotch fir, intermixed with juniper.

5. Region of the Retama, 6270—11061 feet, a species of broom, which forms oases in the midst of a desert of ashes, ornamented with fragrant flowers, and furnishing food to the goats which run wild on the Peak. A few gramineous and cryptogamic plants are observed higher, but the summit is entirely destitute of vegetation

ORGANIC LIFE:—PHENOMENA OF VEGETABLE DISTRIBUTION.

A Pine Forest.

IX. There are many plants which can accommodate themselves to the most diverse climates and localities; and therefore ascend from the plains close to the boundary of vegetable life on the highest mountains. But it is the general law in these cases for such plants to be singularly modified in appearance and anatomical structure as they ascend. The spring gentian, *gentiana verna*, is one of the exceptions, which Raymond found unaltered at all heights in the Pyrenees.

Trees, plants, and bushes, of humbler growth, which occur on the plains and at great heights, are usually much smaller in the latter situation. The leaves, and everything green about them, dwindle with the increased elevation; and the pure, well-defined green is exchanged for an ill-defined light yellow. Singular enough, those parts which seem most capable of resisting cold, as the leaves and stalks, are uniformly subjected to a diminution of their vital functions; while the flowers remain of the same size, are never deformed, and become more dense and richer in their colours. While the *myosotis silvestris* becomes stunted, its flowers assume an intense blue, the admiration of the traveller. The flowers of the pale primrose have a much deeper colour on the top of the Faulhorn, while the plant itself is much smaller than its congener on the Swiss plains. The observations of M. Parrot, among others, are to this effect on the flora of the Caucasus, of Ararat, the Swiss and Italian Alps, and the Pyrenees. The arctic flora is similarly distinguished.

X. The preceding references to different climatic states are, however, perfectly inadequate to explain the phenomena of vegetable distribution. While an analogy is often observable between the plants of different regions under corresponding circumstances of latitude, elevation, and soil, the species are generally found to be different; and usually the botanical character of countries not widely apart from each other, is totally different, though under the same parallels.

Some plants are entirely confined to one side of our planet. The beautiful genus *erica*, or heath, of which there are upwards of 300 species, occurs with breaks over a narrow surface, extending from a high northern latitude to the Cape of Good Hope. But the whole continent of America does not contain a single native specimen; nor has a *pæonia* been found in it, except a solitary one to the west of the Rocky Mountains. On the other hand, the new world contains many families, as the *cacti*, which are not found naturally in the old.

Some plants occur in a single specific locality, frequently a contracted area, and nowhere else. The beautiful *disa grandiflora* is limited to a spot on the top of the Table Mountain at the Cape; and the celebrated cedar of Lebanon appears to be restricted in its spontaneous growth to the Syrian mountains. The small island of St. Helena has an indigenous flora, with a few exceptions different from that of the rest of the globe.

Mountain chains of no great breadth very commonly divide a totally distinct botany. There is a marked difference in the vegetation on the Chilian and opposite side of the Andes, though the climate as well as the soil is nearly the same, and the difference of longitude very trifling. In North America, two completely different classes of vegetation appear on the two sides of the Rocky Mountains. A variety of oaks, palms, magnolias, azaleas, and magnificent rhododendrons occur on the eastern side, all of which are unknown on the western, the region of the giant pine.

XI. The distinct vegetation possessed by various parts of the globe has led to its division into botanical kingdoms, or phyto-geographical regions, named in general after the genera that are either peculiar to them, or predominant in them. The arrangement of M. Schouw, which is usually adopted, discriminates twenty-five great provinces of characteristic vegetation upon the surface of the earth.

In constituting any portion of the globe into a phyto-geographical region, M. Schouw has proceeded upon the following principles:—1. That at least one half of the species should be indigenous in it. 2. That a quarter of the genera should also be peculiar to it, or at least should have a decided maximum. 3. That individual families of plants should either be exclusively confined to the region, or have their maxima there.

XII. The phenomena of botanical geography and the facts of geology are mutually illustrative. The existing dry land having been upheaved above the waters at different epochs, it may be reasonably inferred that each portion on its emergence received a vegetable creation in harmony with its position. The ultimate constitution of the general surface into different botanical kingdoms would hence follow, each of which has preserved its primitive features, while adjoining, and even far distant foci, have to some extent intermingled their respective products, under control of the natural agencies of diffusion.

The agents that involuntarily officiate in the diffusion of vegetable products are the atmosphere, the waters, and many animals.

1. The impulsion of the atmosphere in its calmest state is quite sufficient to transport to considerable distances seeds furnished with downy appendages or winglets, as is the case with many plants, with the minute sporules of cryptogamia, which are light as the finest powder. When ordinary breezes convey the sand-dust of the Sahara a thousand miles or more from the desert, it may be conceived that seeds, which are comparatively heavy, are borne far from home by the hurricane. Two Jamaica lichens, which had never been seen in France before, were found by De Candolle growing on the coast of Brittany, the offspring of sporules which had been swept over the Atlantic.

2. The mountain torrent washes down into the valley the seeds that have accidentally fallen into it, or have been swept away by its overflows; and hence the plants of the High Alps occur on the plains of Switzerland, which are entirely wanting in France and Germany. Rivers answer the same purpose more extensively, and also the oceanic currents. The nicker-tree, one of the leguminous tribe, has been raised from seed borne across the Atlantic by the Gulf stream.

3. Animals of the sheep and goat kinds, with the horse, deer, buffalo, and others, widely disperse several species of plants, the seeds of which, furnished with an apparatus of barbs and hooks, adhere to their coating. Seeds also of various kinds pass through the digestive organs of birds uninjured as to their vitality. The little squirrel buries the acorn in the ground for winter provender, and sows an oak, if prevented from returning to the spot.

XIII. Plants capable of extended naturalization, and serviceable as articles of food or luxury, have been widely disseminated by the human race in their migrations. The cerealia afford a striking example. These important grasses known to the ancients, wheat, barley, oats, and rye, were the gifts of the old world to the new. They are also importations into Europe; but the loose reports of the ancients and the diligent researches of the moderns alike leave us in ignorance of their native seat. Probability points to the conclusion that they have spread from the neighbourhood of the great rivers of Western Asia, the primitive location of the human family; and it is not impossible that in that

imperfectly explored district, or further east on the Tartarian table-land, some of the cereals may yet be found growing spontaneously. The first wheat sown in North America consisted of a few grains accidentally found by a negro slave of Cortes, among the rice taken for the support of his army. In South America the first wheat was brought to Lima by one of the early colonists, a Spanish lady, Maria d'Escobar. An ecclesiastic, Jose Rixi, was the first to sow it in the neighbourhood of Quito.

Maize, or Indian corn, (*Zea mays,*) has been dispersed in the Old World from the New; and also a more important product, the potatoe, (*Solanum tuberosum,*) the use of which now extends from the extremity of Africa to Lapland. In Chili, the native country of the plant, it occurs at present in a wild state. The Spaniards imported it into Spain, and from thence it was communicated to Italy. It was first made known in England at a subsequent period from Virginia, having been received there from the Spanish colonists in South America, as it is not a native of intervening Mexico.

The Grape-vine, so extensively spread over Europe, is probably not indigenous in any part of it. It chiefly owes its diffusion there to the Romans, who received it from the Greeks, to whom it most likely immediately came from the country between the Black and Caspian Seas. The Romans introduced most of the finer European fruit-trees, some from Africa, as the pomegranate, but the great majority from Western Asia, as the orange, fig, cherry, peach, apricot, apple, and pear. A variety of the plum, the damson, or damascene, came from the neighbourhood of Damascus during the Crusades. The name of the damask-rose points to the importation of the plant from the same quarter into Europe.

XIV. The ocean as well as the land has different botanical regions; and changes of the vegetation are observed with the depth analogous to the variation of terrestrial plants with the height. Marine vegetation seems to have its vertical extent determined by the subaqueous range of light, which varies with the power of the sun and the transparency of the water.

CHAPTER II.

ZOOLOGICAL GEOGRAPHY.

THE arrangement of the animal kingdom proposed by the illustrious Cuvier, notwithstanding the great modifications it has undergone, is still the basis of zoological classification. It distributes the forms of animal life into four grand divisions, which are subdivided into nineteen orders:

I. Vertebrated Animals.—(*Animalia Vertebrata.*)

Animals having a vertebral column, which, with its termination, the skull, encloses and protects the brain and spinal cord, the central organs of the nervous system.

1. Mammalia; animals which produce their young alive, and for a time suckle them.
2. Aves—Birds.
3. Reptilia—Reptiles with cold blood.
4. Pisces—Fishes with cold blood.

II. Molluscous Animals.—(*A. Mollusca.*)

Animals of a soft texture, and no skeleton, having the muscles attached to the skin, which produces in many species stony coverings or shells.

5. Cephalopoda, (heads furnished with feet.)—Cuttle-fish, Nautilus, &c.
6. Pteropoda, (wing-like feet.)—Clio, the chief food of the whale, Thyalæ.
7. Gasteropoda, (creeping on the stomach.)—Slug, Snail, Limpet, Whelk.
8. Acephala, (headless.)—Oyster, Muscle.
9. Brachiopoda, (arm-like feet.)—Bivalve Shells.
10. Cirrhopoda, (thread-like feet.)—Barnacle.

II. Articulated Animals.—(*A. Articulata.*)

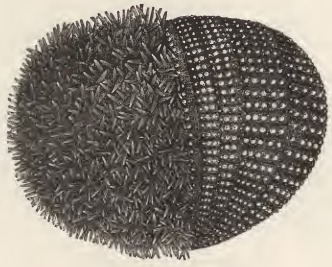
Animals consisting of a number of articulated joints or rings, soft or hard, supplying the place of a skeleton.

11. Annelida.—Worm, Leech, &c.
12. Crustacea.—Crab, Lobster, Shrimp.
13. Arachnida.—Spider, Scorpion.
14. Insecta.—Insects of various families.

IV. Radiated Animals.—(*A. Radiata.*)

Animals which in many instances have their organs arranged like rays proceeding from a centre; also called Zoophytes, or plant animals, from the resemblance of some families to vegetable forms.

15. Echinodermata, (εχινος, a hedge-hog; δερμα, the skin.)—Star-fish, Sea-urchin, &c.



Shell of Echinus, or Sea-urchin.

16. Entozoa (εντος, within; ξωον, an animal.)—Intestinal animals, as the Tape-worm.
17. Acalephæ, (ακαληφη, a nettle.)—Medusa or Sea-nettle.
18. Polypi, (πολυς, many; πους, a foot.)—Sea-Anemone, Coral, Madrepore.
19. Infusoria, microscopic animals.

II. The animal kingdom corresponds with the vegetable in the exuberance and wide diffusion of its inferior organisms. Infusoria occur in numbers which baffle the power of arithmetic to express, or the mind to conceive, living in every variety of situation, in the bed and waters of the ocean, in stagnant pools, the mud of rivers and deltas, in marsh grounds, animal and vegetable juices, in rain, snow, ice, boiling springs, and in peat earth twenty feet below the surface soil. Zoophytes occupy the oceanic waters in vast profusion from the equator to the highest latitudes; the polypi of various families, whose aggregated skeletons compose the coral formations, so beautifully varied, labyrinthine, branching, and

Carvophyllia fastigiata.

Madrepora muricata.

Meandrina labyrinthica.

arborescent, having their special habitation in the equatorial seas. Molluscous animals also evidence the prodigality of animal life, and its wide-scattering under the control of law, different species of marine testacea, or shell-fish, occurring in different parts of the ocean, and at varying depths. The insect class, embracing a vast number of species, is likewise distributed through all latitudes; but many tribes and species are limited to particular spheres, while from the poles to the equator the development of insect life increases generally, and attains its maximum in the equinoctial regions of the western world.

1. Such is the remarkable tenacity of life in the infusoria, that some have been observed to recover after drying in vacuo, along with chloride of calcium and sulphuric acid, for 28 days, after exposures to a heat of 248°.

ORGANIC LIFE:—FISHES, REPTILES, AND BIRDS.

In the Antarctic regions, towards the close of the year 1840, Sir James Ross picked up some brash ice of a brown-yellow colour, not far from Mount Erebus, which was supposed to be due to aluminous matter ejected in fine ashes from the volcano. But upon specimens brought home in sealed glass vessels, being forwarded to M. Ehrenberg, he found the colouring matter to consist of myriads of infusoria, almost the whole of which reached Berlin in 1844, in a living state.

In 1839, Ehrenberg examined the mud-banks in the harbour of Wismar in the Baltic, and found that in proportions varying from $\frac{1}{99}$ to $\frac{1}{3}$, the mass of deposited mud consisted partly of living infusoria, and partly of the siliceous shells of dead specimens. Similar results have been obtained from the deposits in the harbour of Pillau, of the Elbe at Cuxhaven, and of the Nile, from which it appears, that the bars and deltas formed by river deposits, are not due solely to the mechanical transport of soil, but, at least in some cases, are also caused by the agency of animal organisms undiscernible to the naked eye.

2. Among molluscous animals, the marine testacea are widely different in the tropical, polar, and intervening seas. They vary also with the longitude. The shores of America and New Holland have distinct species of shell-fish; and the east and west coasts of tropical America have only one species in common. The pearl oyster only comes to perfection in the equatorial ocean; and the *pinna marina* thrives only in the Mediterranean and Indian Seas. Some species have a much wider range than others, identical examples occurring at the Gallipagos and Philippine Islands, on opposite sides of the Pacific and in the Arctic and Antarctic waters. The east coast of America and the opposite coast of Europe have also several kinds in common. In many cases, by adhering to ships, marine testacea have been disseminated in the ocean far from their natural sphere, to be permanent in a foreign locality.

Maia, or Sea Spider.

In the eastern parts of the Mediterranean, according to the recent researches of Professor Forbes, shell-fish attain their maxima, as to the number of individuals and of species, between the surface and the depth of 12 feet. At the depth of 210 feet, with a greatly diminished temperature, nearly 50 per cent. of species were identical with northern forms, marine depths thus corresponding to terrestrial elevation with reference to organic life. The general limit of organic life in that part of the Mediterranean is at the depth of 1800 feet. But its existence in the profound depths of the ocean, contrary to the general opinion of naturalists, was ascertained by the recent Antarctic expedition. On several occasions the dredge brought up from the depth of 6000 feet, sand, mud, and stones, with living molluscs, which were recognised by Sir James Ross as identical with species common to the Arctic waters. "The only way," he remarks, "they could have got from the one pole to the other must have been through the tropics; but the temperature of the sea in those regions is such that they could not exist in it, unless at a depth of 12,000 feet. At that depth, they might pass from the Arctic to the Antarctic Ocean without a variation of 5° of temperature; whilst any land animal, at the most favourable season, must experience a difference of 50°, and if in the winter, no less than 150° of Fahrenheit's thermometer—a sufficient reason why there are neither quadrupeds, nor birds, nor land-insects, common to both regions."

3. The highest latitude at which insect life has been observed is 82° 26′ 44″, where, on the last day of Captain Parry's attempt to reach the North Pole over the ice, a species of *aphis* was found, about 100 miles from the nearest known land.

Scorpion.

III. The more important division of the animal kingdom, which includes the vertebrated forms, followed ascendingly, commences with the ordinary inhabitants of the waters—bony or cartilaginous Fishes with cold blood. While peculiar tribes are confined to the freshwaters of particular districts, each large basin of the ocean appears to have its distinct genera and species. The *habitat* of various families is well known.

The genera of which carp and perch are the types, *cyprinus* and *perca*, appear in almost all the rivers of the temperate zone.

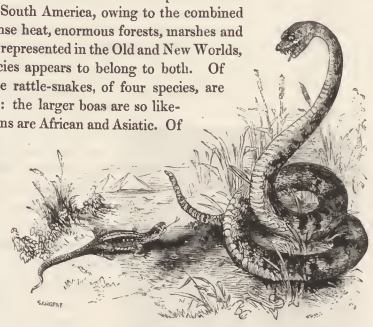
The *gymnotus electricus*, or electrical eel, which can destroy powerful quadrupeds by the discharge of its galvanic battery, inhabits the rivers and pools of equinoctial America, while fishes similarly endowed, but to a less degree, occur in other spheres, as the *silurus electricus* in the rivers of Africa, and the *torpedo* in the Mediterranean.

Sharks roam in the deep open oceans of tropical and warm climates. Sturgeons occupy land-locked waters, as the Baltic, the Caspian, and the Black Seas, with large rivers, the Volga and the Danube. The cod dispersed through the North Atlantic, congregate chiefly upon the great sand-banks to the south-east of Newfoundland. Flying-fish are principally intertropical, or, at farthest, never go beyond the parallel of 40°, their most active enemies, the *coryphanæ*, named giltheads from their brilliant colours, observing the same limits.

The European salt and fresh waters contain 853 species of fish, of which the waters of Britain and Italy have only 100 in common. The species identical in the Mediterranean and Black Seas amount to no more than 27, notwithstanding the contiguity of the two basins and direct intercommunication. Almost all the fish of the Caspian are specifically distinct from those in other parts of the globe.

Several kinds of fish are eminently social and migratory. The herrings issue every year from the depths of the Arctic Ocean, and repair in vast shoals to the coasts of Western Europe, the United States, Kamschatka, and the Aleutian Isles. The tunnies annually visit the Mediterranean from the Atlantic. The object of the migration has not been satisfactorily ascertained, but both of the commonly assigned causes may operate, the deposition of the spawn in shallow water, and the search for food.

IV. Reptiles, the next order, occupy the lowest rank among terrestrial vertebrata. They diminish in number, magnitude, and noxiousness, from the equator to the poles; and have their maximum development in the equatorial regions of South America, owing to the combined circumstances of intense heat, enormous forests, marshes and rivers. Each family is represented in the Old and New Worlds, but not a single species appears to belong to both. Of the serpent tribe, the rattle-snakes, of four species, are exclusively American: the larger boas are so likewise, whilst the pythons are African and Asiatic. Of crocodilians, consisting of three genera, the crocodile proper is distributed in the Old and New Worlds, but the species differ; the alligator or cayman, is confined to America; and the gavial is limited to the Ganges and the other large rivers of India. No living crocodilian has ever been known in Europe; and excepting the Marianne Isles, all the reptile tribes are entirely wanting in the islet groups of Oceanica.



The ascertained number of species belonging to the four divisions of reptiles is as follows:

Chelonia (Tortoises)	69
Sauria (Lizards)	203
Ophidia (Serpents)	265
Batrachia (Frogs)	120
Total of species	657

Very few reptiles reach the north boundary of the temperate zone, taking the isotherm of 30° for its limit. Frogs and salamanders go the farthest north.

V. Birds, the members of the succeeding order, have a more perfect organisation; and being endowed with the power of rapid locomotion, several species are wide geographic rangers. This is the case with the house-sparrow, common crow, gosshawk, jay, raven, osprey, or fishing eagle, cliff-swallow, and others. But the majority of species are restricted by geographical laws to particular districts, and have in many instances a very local existence. The far-famed birds of Paradise are confined to New Guinea and the neighbouring islands; the condor never leaves the Andes of South America; the great eagle remains among the ridges

of the Alps; parroquets are chiefly intertropical; the albatross is seen skimming the surface of the ocean on approaching the parallel of 40°; the common grouse, the yellow and pied wagtails, and the English starling, are alone known in Great Britain. These are only a few examples of limited distribution. The most beautiful varieties of birds are found within the tropics; where also the number of species and individuals is the greatest, except in the instance of two families, the swimmers and waders, which in both respects are the most numerous in higher latitudes.

The Bustard.

Birds are distributed into the following six divisions: 1. Rapaces—Birds of prey; 2 Scansores—Climbers; 3. Oscines—Songsters; 4. Gallinaceæ—Gallinaceous birds, *gallina*, a hen; 5. Grallatores—Waders; 6. Natatores—Swimmers. The known number of species is upwards of 6000.

Several families have extraordinary powers of locomotion. The hawk and swift can traverse 100 miles in an hour: the eider-duck 90: the common crow 25.

Some birds are solitary, but most families are eminently gregarious, and associate frequently in countless numbers. Immense flocks of sea-fowl of different kinds occupy the vogelbergs, Bird-rocks, of the Faroe Islands. One of the most remarkable, in the harbour of Westmannsharn, on the west of the island of Stromoe, lies in a frightful chasm, entered by a narrow passage, encompassed by high precipitous cliffs. Here thousands of birds occupy a particular rock, each kind having its respective domicile. The glossy cormorants are on the lowest shelves; the voracious skua gulls are above; next come the kittiwakes in crowded rows; higher up is a closely packed colony of auks and guillemots; puffins, scarcely visible, occupying the loftiest station. It is singular, that of twenty-five vogelbergs in Faroe, all open westward, and none eastward, though apparently the situations in that direction are equally advantageous. The preference is due to the greater prevalence of westerly winds, birds in general flying against the wind when departing on a cruise, in order to have its assistance when returning weary.

Many birds alternate regularly between two distant countries as food becomes scarce or abundant by the change of seasons. Swallows, storks, cranes, kingfishers, nightingales, abandon the northern parts of Europe for the southern, even passing over into Africa, on the approach of winter. Vast quantities of aquatics feeding on fish interchange the basins of the Orinoco and Amazon, as the annual inundations of those rivers, which are six months apart, afford a more plentiful supply. Humming-birds advance from the south into the northern parts of the United States, and into Canada, as the return of spring causes millions of plants to expand their blossoms. Some birds migrate singly, others in flocks, and others in vast armies. Alexander Wilson, in North America, estimated a flock of passenger pigeons which continued to pass above him for the greater part of a day to have been a mile in breadth by 240 in length, and to have contained (three birds being assigned to the square yard,) at least 2,230,272,000 individuals.

Birds occupy the whole globe. Voyagers in high latitudes have never gone beyond their horizontal range, while the habitat of the condor extends perpendicularly from the plains to the level of the loftiest crests of the Andes.

The Adjutant.

VI. Quadrupeds or mammalia, stand at the head of the animal creation, distributed into eight great groups. They differ vastly in appearance and habits, but correspond in the one particular of suckling their young. The groups with some of their types are as follows:

1. *Quadrumana*, (four-handed.)—Monkey, Apes (*Simiæ.*)
2. *Carnivora*, or *Carnassiers*, (flesh-eaters.)—Mole, Glutton, Civet, Bear, Hyæna, Cat, in which last tribe the sanguinary development is at his height in the lion and tiger, sea-otter.
3. *Marsupialia*, (pouched.)—Opossum, Kangaroo, Wombat.
4. *Rodentia*, (gnawers.)—Beaver, Porcupine, Squirrel, Jerboa.
5. *Edentata*, (toothless.)—Sloth, Armadillo, Ornithorynchus.
6. *Pachydermata*, (thick-skinned.)—Elephant, Rhinoceros, Hippopotamus, Zebra, Tapir.
7. *Ruminantia*, (chewing the cud.)—Camel, Ox, Goat, Sheep, Deer, Antelope, Giraffe.
8. *Cetacea*, (belonging to whales.)—Whale, Dolphin, Narwhal, Seal, Porpoise.

VII. The first group has no representatives in a wild state in Europe, except on the rock of Gibralter, whose inaccessible heights have long been occupied by a race of monkeys identical with the Barbary ape. It is not represented either in North America, Australia, or Oceanica. The region of four-handed quadrupeds extends in the New World from central America through the intervening districts to the pampas of Buenos Ayres; and in the Old World, it includes the whole of Africa exclusive of Egypt, the South of Asia, and the Indian Archipelago.

Chimpanzee.

The monkey tribe contains 170 species exhibiting wide differences in form, size, colour, and habits. There is no species common to the two continents; but very few are common to Africa and Asia; peculiar genera having for the most part contracted geographical limits.

In the Old World there are 72 species tailed, and 7 tailless. The baboons, the most numerous of the tailed families, are principally located in Africa; the gibbons, or long-armed apes, a tailless genus, are exclusively Asiatic. The station of the interesting tailless family of orang-outang, "the man of the woods," is both African and Asiatic, but entirely local, and the individuals are rare. The red species appears in Borneo, Sumatra, and Malacca: the black species occurs on the coasts of the Gulf of Guinea.

In America there are 91 species, none tailless, and all more gentle, but having a more decided animal appearance, than their congeners on the eastern continent. They are divided into two classes, the sapajous and sagouins, according as they have or have not propensile tails, by which they suspend themselves, and swing from bough to bough. Of the sapajous, the "weepers," so called from their plaintive cry, are the most local; and the "howlers," whose howling may be heard at the distance of a mile, the most widely distributed.

Distinct from the Simiæ, but belonging to the group of quadrumana, is the Makis tribe. It occurs in Asia, but the type, the genus Lemur is entirely confined to Madagascar, the adjacent islands, and Mozambique. The Lemurs, remarkable for bounding elasticity, boa-like tails, and inoffensiveness, live in troops upon the trees, and apparently supply the place of the monkeys, none of which have yet been observed in Madagascar.

VIII. Carnivorous animals of some kind or other are spread over the entire globe, as their natural food exists in every accessible region; but there are certain limits to which whole races are confined, while the different genera and species are restricted to narrower bounds. Two tribes of the family *Digitigrada*, may be noticed. 1. *Canis*, (dogs.) The dog, properly so called, domesticated by man, has attended him everywhere, his faithful companion and friend; but there are two remarkable instances of the existence of dogs in a wild state, the dhole of India, and the dingo of Australia, besides a half-reclaimed race among the Indians of North America, and another partially tamed in South America. The jackal, the

Australian Dingo.

characteristic dog of Africa, ranges through its entire north to India, and from Abyssinia to the Caspian Sea. The wolf is more widely distributed; in America, from beyond the Arctic circle to near the isthmus of Panama; in the Old World, from the same northern limit to Egypt, Arabia, and India, and from Spain on the west to the eastern shores of the continent; not however occurring in India beyond the Ganges. But of all the members of the dog tribe, omitting the

ORGANIC LIFE:—THE CARNIVORA, MARSUPIALIA, AND PACHYDERMATA.

domesticated, the fox is the most extensively diffused, from the highest northern latitudes through great part of Europe, Asia, Africa, and America. The various species are provincial. The red fox, distinct from the European, inhabits the forest district of North America; the black fox, the Siberian woodlands; and the white fox, the polar regions, coming down in midwinter for food to near the parallel of 50° in the western world. 2. *Felis*, (cats.) Europe has no representative of the feline tribe in a state of wildness but the cat and lynx. The wild cat occurs in most of its woody countries, and is found also in Northern Asia, India, and Southern Africa. The feline tribe appears to have no representative whatever in Australia and Oceanica. But the tropical regions of both continents are occupied by powerful animals of the class, lions, tigers, leopards, and lynxes, some of which extend far into mean latitudes. The African lion is found through the whole of that vast peninsula, excluding the Lybian Desert, the Nile countries, and some adjacent districts; the Asiatic lion, specifically distinct, has much smaller domain, stretching from Persia into India; the American lion, the puma, a widely different animal, ranges from Patagonia to the Canadian lakes. The tiger is exclusively Asiatic, occupying the south-eastern countries, with the islands of Sumatra and Java, appearing westward in Persia, and northward in the vicinity of lake Baikal. The leopard and panther, two closely related animals, if not specifically the same, chiefly inhabit Senegambia, the oases of the Great Desert, India and its islands. The jaguar, sometimes called the American

The Jaguar.

panther, a distinct animal, is peculiar to the south part of the continent, and is principally found in Brazil and Paraguay. Lynxes are common to Europe, Asia, Africa, and America, but the species are different.

Hyænas, martens, skunks, otters, civets, represent other tribes of the family of Digitigrades (animals walking on the toes only). The striped hyæna is found in nearly the whole of Africa, and in the southern countries of Asia, extending to the chains of the Caucasus and Altai: the spotted hyæna is entirely African, inhabiting the south, especially the neighbourhood of the Cape colony. The marten tribe is represented in each grand division of the globe; but the more important species, on account of their furs, the ermine and sable, *Mustela erminia* and *M. Zibellina*, have their province in the northern parts of the two continents. Otters haunt most of the rivers, lakes, and coasts of Europe and America; but two species of the sea-otter, the most valuable of the fur-bearing animals, *Lutra marina* and *L. phocula*, are peculiar to the extreme north-eastern shores of Asia and the north-western shores of America, the Aleutian, and other intervening islands.

Of carnivora, belonging to the family of Plantigrades (animals supported in walking on the entire sole of the foot), the most important is the bear tribe (*Ursi*). The European brown bear, which still haunts the recesses of the Alps and Pyrenees, is distributed through the entire north from Norway to Kamschatka, and appears in Japan. The American black bear inhabits all its densely wooded districts from Carolina to the Arctic Sea, and from the Atlantic to the Pacific. The grissly bear, the most formidable species, has a much smaller province, consisting of the Rocky Mountains, and a portion of the eastward territory. The polar bear occupies the icy zone, sometimes extending his excursions southward on the shores of Hudson's Bay and Labrador to the parallel of 55°, appearing also on the northern coasts of Europe and Asia. Abyssinia, Syria, Thibet, and Sumatra, have each different species.

IX. None of the marsupials, quadrupeds furnished with a pouch in which the females carry their young while very small and imperfectly formed, appear on the eastern continent: America has one family, the opossums, spread from the northern United States to the south of the Plata; but the group specially characterises the fauna of Australia, the Moluccas, and New Guinea, constituting in that region one of the best defined zoological kingdoms on the surface of the globe. The Rodents, or gnawers, named from the manner in which they file or gnaw their food with their front teeth, are very extensively diffused, the *muridæ*, or rat tribe, which comprises more than half the species in the group, having the greatest geographical range. The Edentata, or toothless animals, characterised by the absence of front teeth, peculiarly belong to Central and South America, and only occasionally occur in the southern regions of the Old World.

1. Of marsupials, the typical animal, the kangaroos, first discovered by Captain Cook, are found in all the explored parts of Australia, in Van Diemen's Land, New Guinea, and in one instance in Java. The species, about 40, vary greatly in size, from that of a rabbit to the height of a man.

2. Among rodents, the interesting beaver genus ranges in the northern and temperate regions of America, Europe, and Asia. The North American beaver has its furthest northern limit on the banks of the Mackenzie River in lat. 67½° or 68°; its southern boundary is about the confluence of the Ohio and Mississippi, lat. 37°; east and west it extends from the Atlantic to the Pacific, excepting the barren districts. The beaver of the Old World inhabits the rivers between the parallels of 36° and 67°.

The Beaver.

In Asia, it is found on the Obi and its tributaries, but is rare east of the Yenesei. In Europe it occurs, living in burrows along the banks of the Danube, the Rhone, and the Weser. In the Transactions of the Berlin Natural History Society for the year 1829, an interesting account is given of a colony of from fifteen to twenty individuals, settled for more than a century and a half on the small river Nuthe, a short distance above its confluence with the Elbe, in a lonely canton of the Magdeburg district. The little beaver, or the musk-rat of Canada, is a generically distinct animal, but along with the true beaver is incessantly pursued by man for its fur.

The common porcupine, another peculiar rodent, extends from Spain through Southern Europe into Affghanistan and India.

3. Of edentata, the sloths and armadillos are exclusively American: the former extend from the south of Mexico to Rio Janeiro, inhabiting the dense forest districts; the latter occur from the banks of the Orinoco to the most southern parts of the continent, in the open plains and pampas. The great ant-eater, the largest of all the toothless animals, is distributed from the pampas of Buenos Ayres to the north of the Orinoco. Among the edentata of the Old World, the pangolins, or scaly ant-eaters, are common to Africa and Asia: the long-tailed pangolins inhabiting Senegal and Guinea, and the short-tailed pangolins Bengal and Southern China. Australia has the porcupine ant-eater, so named from its covering of spines, as well as its food, chiefly found in New South Wales and Van Diemen's Land; and the ornithorynchus, apparently restricted to the south-east, the most singularly-formed of all mammalia, having a compressed muzzle resembling the bill of a duck, and webbed feet.

X. The Pachydermatous, or thick-skinned group, comprises the largest and most powerful of all the land animals, with some of the most useful as domesticated by man. 1. *Elephas* (Elephants). There are two species of the elephant inhabiting two distinct regions. The Asiatic species ranges from the lower slopes of the Himalaya Mountains through all India on both sides of the Ganges, through the peninsula of Malacca, the south of China, the islands of Sumatra and Ceylon. The white elephants, so highly prized by the potentates of the east, are merely varieties. The African species, of smaller size, and supposed to be more ferocious and less sagacious, extends from the northern borders of the Cape colony to Senegal on the western side and Abyssinia on the eastern. 2. *Rhinoceros*. There are seven species of these huge quadrupeds, none of which are possessed in common by Africa and Asia. Four species belong to Africa, and three to Asia. In both regions, the range of the rhinoceros is nearly the same as that of the elephant, the chief exceptive case being that of the island of Java, where the elephant is wanting, and the rhinoceros occurs. 3. *Hippopotamus*. Some naturalists have discriminated three species of the river-horse, but there appears to be only one, entirely confined to the rivers and lakes of Africa, extending from the Upper Nile in Dongola on the north-east, the streams of

Senegambia on the north-west, and the central lake Tchad, to the Gariep, or Orange River, and its affluents on the south.

The New World has no animal of any kind comparable to the huge Pachyderms of the Old. The tribe of tapirs is common to both, two species of which are located in South America, and one in Sumatra, Borneo, and Malacca. The remaining important tribes of the pachydermatous form are those of the horse and hog.

1. *Equus* (Horses). The Horse, properly so called, now diffused in a domesticated state over the whole civilised world, cannot be traced to his native country. The period when the animal alone existed in a state of nature, or was first reduced by man to obedience and servitude, is equally lost, though it certainly goes back to the most ancient times. At present, the horse runs wild on the table-lands of Central Asia, supposed by some to be the primeval home of the tribe; but more probably this is simply an instance in which the descendants of a domesticated race have returned to a state of wildness. In the same way the animal introduced into South America from Europe by the Spaniards, in their early visits to that continent, now roves wild in immense herds over the vast llanos and pampas.

The Ass, a member of the same tribe, was perhaps domesticated at an earlier period than the horse. There are several species wild, occurring in the countries between north-eastern and south-western Asia. The wild ass of the Tartars (Koulan) inhabits central Asia from about north latitude 48°, to the basin of the Indus. In summer, the animals are common about Lake Aral, but in autumn they migrate in great droves under the conduct of a leader, proceeding to the southern districts of Cutch and Guzerat to pass the winter, returning northwards in the ensuing spring. The wild ass of the Moguls (Djiggetai) roams in troops the sandy deserts of Mongolia, on the borders of Thibet and China. Though hardy in many of his habits, the ass does not support cold so well as the horse, and is hence a far inferior animal at the parallel of 52° in Europe, than his Asiatic brethren between the parallels of 20° and 40°.

The Quagga, belonging to the equine family, and also the zebra, are peculiar to Africa. The beautiful, gaily-striped, but vicious zebras, extend from Abyssinia to the borders of the Cape colony, and appear in Congo and Guinea. The quaggas, of smaller stature, and marked with fewer stripes, occur farther south, below the Orange River. The individuals of each associate in troops, but the two do not herd together. The strange grouping has been sometimes witnessed of ostriches with zebras or with quaggas wandering in company over the plains.

2. *Sus* (Swine).—There are no members of the swine tribe indigenous in America; but a cognate genus, the peccary, of two species, occurs in South America; and since the introduction of the domestic hog, it has run wild, and forms large herds in the western world. Another cognate genus, the wart hogs, is peculiar to Africa. Of true swine, there are several species distributed over the islands contiguous to Southern Asia, and also found in the adjacent continental parts; but the best known species, the European wild boar, has the most extensive range. It occurs generally through the Old World from France eastward to the Asian shores of the Pacific, but is not found in Spain, Italy, and Persia. Its farthest northern limit is in Asia, at about the parallel of 60°.

XI. The group of Ruminants, characterised in their internal economy by four stomachs for the purpose of chewing the cud, comprehends various tribes remarkable for elegance of form, and utility to man, as articles of food and beasts of burden, in climates of the most extreme heat and cold. 1. *Camelus* (Camels). The region of the camel extends from the Canary Isles, through Northern Africa, Arabia, Syria, Asia Minor, Persia, north-western India, the southern districts of Tartary, to the frontiers of China. There are two species, the Bactrian camel distinguished by two hunches on the back, and the Arabian camel with only one, of which the dromedary is a fleet variety. The camel is alone found in a domesticated state. The Bactrian species has been said to run wild in the great Desert of Gobi; but Cuvier remarks, in explanation, that the Calmucks liberate all animals, upon a principle of religion, when their tasks are over. 2. *Auchenia* (Llamas). The camels of the East are represented in the western hemisphere by three species of llamas, remarkably resembling them, but smaller, and without hunches. They are entirely South American, and principally found on the west side of the Andes, from New Granada to the Straits of Magellan, being most common in Patagonia, where the disturbing intrusion of man has been least experienced. Mr. Darwin noticed a habit of this tribe, that of having favourite spots in which to lie down and die, generally in bushy places near the rivers, where at several points the ground was white with their bones—a fact of importance, as illustrative of the frequent occurrence of uninjured bones in caves, or buried beneath alluvial accumulations, and also of certain animals being more commonly embedded than others in sedimentary deposits. 3. *Camelopardalis* (Giraffes). The ruminants of this tribe, so remarkable for their height, peculiar form, swan-like necks, timidity and gentle manners, are exclusively African. There are at least two species, the North African giraffe, inhabiting Nubia, Abyssinia, and the countries around Lake Tcard, and the South African giraffe, which extends from the borders of the Orange River probably into the central regions.

The remaining ruminantia are comprehended in the deer, musk-deer, antelope, goat, sheep, and ox tribes.

1. *Cervus* (Deers).—This genus includes all those ruminating animals which are furnished with solid horns or antlers. The families and species are numerous, and of great importance in the economy of nature.

The Elk or Moose-deer, a gigantic animal, with broad, solid, and very heavy antlers, belongs to the northern regions of both continents. The American elks were formerly found as far south as the Ohio, but at present they only occur further north, in the Bay of Fundy and beyond the Great Lakes, extending from the latter to the mouth of the Mackenzie River on the shores of the Arctic Sea, in lat. 69°. The growth of the willow, upon the tender twigs and leaves of which the elks feed, being promoted by the rich alluvial deposits of the river, is the cause of this high northern distribution, for east and west they are not found beyond lat. 65°. The European elk, a distinct species, very rarely passes north of the parallel of 64° in Scandinavia, and ranges from thence into the interior of Asia, descending more to the south.

The Stag

The Rein-deer is more capable of enduring cold than the elk, and hence occupies the highest latitudes. Its southern limit is the parallel of 60° in Scandinavia, but that of 50° is gradually approached in the severer climate of northern Asia. Though indigenous in Spitzbergen and Greenland, it did not occur in Iceland before the middle of the last century, when three individuals from Norway were turned loose, whose descendants roam in herds in the mountainous regions. No animal renders more important services to the human population of its district. Hence the few wild herds that remain in the Old World are constantly diminishing, every art being employed to reclaim and domesticate the individuals. The American rein-deer, the caribou, occupies the entire continent north of a line passing across it in about the latitude of Quebec. It was found in Melville Island by Captain Parry's expedition, and was seen in great numbers on the Isthmus of Boothia during Ross's last voyage.

The Fallow-deer, the well-known ornament of our parks, is common also in confinement in various parts of Europe, but is said to run wild in Lithuania and Moldavia. It occurs in Greece, Palestine, Persia, China, and Northern Africa, and is referred by Cuvier to Barbary as its native home. The fallows of the Old World are represented in the New by the Virginian deer, common in that State, but distributed from Canada to the northern parts of South America.

The common Stag or Red-deer, ranges from Great Britain, through western and midland Europe, excluding the greater part of Russia, to the north shores of the Caspian Sea, and from thence through the interior of Asia to Lake Baikal. It seems to be represented in North America by the wapiti.

The Roebuck, peculiar to the Old World, inhabits the midland provinces of Europe and Asia. Though plentiful in the Highlands of Scotland, it has disappeared from England and Wales, and appears not to have been known in Ireland.

2. *Moschus* (Musk-deers).—This tribe, characterised by the absence of true antlers or horns, and a secretion of musk, comprises seven species, two belonging to Western Africa, four to India and the Archipelago, and one, the genuine musk-deer, to central and south-eastern Asia.

3. *Antelope* (Antelopes).—Africa, deficient as to the deer tribe, is peculiarly the land of the antelope, the most numerous in species of any race of ruminants, differing widely in size, colour, habits and station. A few court the shade of the forests; some inhabit the lofty table-lands; but the greater number roam in the plains in troops. The gazelle, long celebrated for its large, mild, and black eyes, is found in Egypt, Barbary, and through all the country bordering on the Great Desert. Of two European antelopes, one is the chamois, so remarkable for its agility, dwelling on the highest ridges of the Pyrenees, and Alps, the Carpathian and Greek mountains, Caucasus and Taurus.

4. *Capra* (Goats).—The several species are mountain dwellers, as the ibex, which inhabits the highest ranges of Europe; the penang, found on the rudest points of the Caucasus and the inhospitable hills of Persia; the goat of Cashmere, occupying the declivities of the Himalaya and the upland plains; the jaal goat, belonging to the Sinaitic Mountains, those of Upper Egypt, and Abyssinia; and the Rocky Mountain goat of North America, attached to its loftiest and least accessible summits. The parent stock of the common domesticated goat is unknown. There are still a few running wild in Wales.

5. *Ovis* (Sheep). The wild races like the preceding are chiefly denizens of mountainous districts. The greatest number of species occurs in Asia. The Asiatic argali, with enormous horns, extends from Kamschatka on the north-east, through the Mongolian deserts, and central mountains, to the steeps of Caucasus on the south-west. The North American argali, or Rocky Mountain sheep, inhabits the range from which it derives its name, and the ridges which intersect the country from thence to the Pacific, between the parallels of 40° and 68°. The mouflon occupies the heights of Corsica, Sardinia, Crete, Cyprus, and other islands of the Greek Archipelago. It is quite uncertain from what race the domestic breeds are descended.

6. *Bos* (Oxen). The largest and most powerful of all ruminant animals belong to this tribe. It comprises several species.

The common Ox, a native of the Old World, now living as far as the parallel of 64°, and in Lapland even under that of 70°, appears to have sprung from the warmer parts of the temperate zone; and probably descends from the *Urus* of the ancients, an extinct race, but described by Cæsar as inhabiting the great Hercynian Forest. The white wild cattle of a few English parks are usually supposed to be the original stock, but it is far more likely that they represent a race which has been allowed to return from domestication to wildness. The Brahminy bull, a sacred animal in most parts of India, is distinguished by a hunch on the back, and the skin of the neck being furrowed with transverse wrinkles.

The Gayal, an Asiatic species, differing from the ox, which has thirteen pairs of ribs, by having fourteen, inhabits the southern and south-western slopes of the hills secondary to the Himalaya, and occurs both wild and domesticated.

The Yak, the mountaineer of Central Asia, is the highest ranger of the bovine tribe. Where the mean annual temperature is below the freezing point, is its appropriate climate. Hence it lives amid eternal snow on the table-land of Pamir, the "Roof of the World," at the height of 15,000 feet. The fine-haired bushy tail of the animal furnishes the well-known *chowry* of Hindostan, used as a fan, and an oriental insignia of rank. When a pacha of so many tails is mentioned, it means the number of tails of the yak which according to his dignity he is allowed to have carried on state occasions.

The Buffalo, confined to the eastern continent, is native to India and Southern Africa. The Indian species, almost universally domesticated in its original country, has been widely extended in that state; eastward to China and the Philippines; westward to Europe below the Alps, and Africa north of the desert. The buffalo of Southern Africa, a much more formidable animal, has never been tamed.

The Bison is common to the eastern and western world, but the species differ. While the ox has thirteen pairs of ribs, the European bison has fourteen, and the

The Bison.

North American fifteen. Both species are remarkable for their daring energy, but the former is nearly extinct, and the latter, though still numerous, is rapidly diminishing. The European bison, or auroch, a forest animal, which was abundant in Germany in the time of Charlemagne, occurs in the countries around the Black and Caspian Seas: the American bison, popularly but erroneously called buffalo, an animal of the open savannahs, roams westward of the Mississippi, and on both sides of the Rocky Mountains, having for its extreme southern and northern limits probably the parallels of 35° and 64°.

The Musk-ox, peculiar to North America, named from the odour of its flesh, has a confined range extending from the parallel of 60° to that of 74° in Melville Island.

XII. The Cetacea, animals of the whale kind, form the last group of mammalia. Popularly considered as fishes, and resembling them in external appearance and habitat, they have the internal structure, vital functions, and mode of production of land quadrupeds. There are several families, chiefly occupying the seas of high latitudes, comprehending the whales properly so called, with narwhals (sea-unicorn), porpoises, and grampuses.

In former ages whales were frequent in the Mediterranean, along the British shores, and in the Bay of Biscay. In the latter locality the modern whale-fishery commenced, conducted by the inhabitants of the shores, the Basques on the Spanish side, the Bearnese and Gascons on the French. It is only at present very rarely, and as an animal astray, that one of the huge cetacea appears in such a low latitude. In February, 1848, an individual was captured in the Channel between Hythe and Folkstone. The common black or Greenland whale, the chief object of the pursuit of man, has largely left those seas during the present century, and gone farther north. A return of the whale-fishery conducted in the northern seas by British ships from the year 1815 to 1834, shows the smallest number captured to be 161 in the year 1830, the greatest number to be 2,018 in the year 1823, and the average annual number during the period stated, to be 1,024¼. The spermaceti whale, or cachelot, is a much more ranging animal than its congener, descending in the North Atlantic to Newfoundland, and even to the Azores, and abounding in the Southern Ocean. The white whale occurs in all the Polar Seas, but is especially abundant in the North Pacific towards Behring's Strait. In the Antarctic Ocean, into which man has seldom intruded, whales of various kinds occur in great numbers, and to that quarter of the globe the attention of whaling adventurers is now strongly directed.

The Narwhal is located near the polar ice, but individual instances of wandering from it to some distance are not uncommon.

The common Porpoise is plentiful in all the European seas, especially along the coast of North America and the west coast of Ireland.

The common Grampus ranges through the Northern Ocean, and occasionally appears off the coast of Great Britain.

All the preceding cetacea are carnivorous; but there are three genera which are exclusively herbiverous:

1. *Manatus*, locally known as the sea-cow. 2. *Halicore*, daughter of the sea, or sea-lass. 3. *Stellerus*, a name derived from Steller, the first person who observed and described the animal. The manatees occur in some of the tropical rivers of Western Africa; but ascend in far greater numbers those of South America, the Orinoco, and the Amazon, occurring also in shallow bays among the West India Islands. The halicore, or dugong, a more marine animal, remarkable for the devoted attachment subsisting between the mother and the young, has its head-quarters in the Asiatic Archipelago. The steller, which is said to average when full grown a length of 25 feet by 18 at the greatest circumference, inhabits the North Pacific, where it occurs on the coasts of America and Asia.

Seals and Walruses form a distinct family in Cuvier's group of carnivora, but are frequently classed with cetaceous animals. The number of the seal species is very considerable. They inhabit the frozen and higher parts of the temperate zone in both hemispheres. The common seal is extensively diffused in these regions; other species are very local. The ursine seal, or sea-bear, is found exclusively in the North Pacific, towards Behring's Strait: the lion seal, or sea-lion, occurs on the north-eastern shores of Asia, chiefly between the parallels of 40° and 60°. The walrus, or morse, of which but one species is known, is more decidedly confined to the high latitudes.

See Zoological Map showing the Distribution of principal Mammalia.

XIII. It appears from the phenomena of animal distribution, that the globe may be divided into the following great zoological kingdoms, each of which is characterised by a fauna peculiar to itself, and may generally be further subdivided into provinces distinguished by the exclusive possession of certain forms: 1. The Arctic Region, comprehending the northern parts of Europe, Asia, and America, and the district from thence to the pole, to which the same animals are common, but strikingly different from those of other latitudes. 2. The North Temperate Region, in which the species are often identical in Europe and Asia, though more frequently differing, while they are all peculiar in America, which possesses also some distinct genera. 3. Region of Intertropical Asia with the Archipelago, characterised by huge pachyderms, and an intense development of the feline tribe. 4. Region of Intertropical and Southern Africa, to which entire genera of pachyderms and ruminants are confined, with a vast variety of species of the latter race. 5. Region of Intertropical and South America, distinguished by the prevalence of edentata, the occurrence of various genera of other tribes which are peculiar to it, and the absence of every species common to the eastern world. 6. Region of Australia, remarkable for the feeble development of mammalia, with one exception, that of the marsupials, to which almost all the land quadrupeds belong.

XIV. The Antarctic regions, as far as they have yet been explored, appear to have no land animals, contrary to what is the case in the opposite dark and outer boundary of the earth. The Arctic Zone is tenanted by white bears, rein-deer, wolves, the polar hare, and arctic fox, some of which seek no southerly migration to avoid the long rigorous winter. While Parry wintered at Melville Island, a pack of wolves nightly serenaded the crew; and a beautiful white fox was taken and domesticated. But no terrestrial quadrupeds have hitherto been observed on the south polar shores. The oceanic birds, albatrosses, penguins, and petrels, occur in great numbers, with seals reposing on the ice, and whales spouting in all directions in the open water.

XV. Intertropical and the adjoining countries strikingly contrast with other latitudes in being peculiarly the home of carnivora of the feline tribe, lions, tigers, leopards, panthers, lynxes, and jaguars, of which the comparatively small and feeble wild cat is the only representative in northern regions. The same remark applies to the viverrine, or civet tribe, of which the genet is the only European example; and also to the hyænas, with their allied races. On the contrary the

canine tribe, wolves and foxes, excepting the jackal; and the marten tribe, weasels, stoats, ferrets, pole-cats, and others, are most abundant in mean and high latitudes. But of all the land carnivorous tribes, comprising upwards of 500 species, the proportion of species in tropical and temperate regions, is nearly as 3 to 1.

XVI. Contrasting the quadrupeds of the western and eastern hemispheres, we find a much smaller proportion of those that are useful to man in the former than in the latter. The llama, vicugna, turkey, some sheep and dogs, comprise all the important contributions made by America to the domestic stock of animals, which are vastly inferior to the domesticated races it has received from the Old World. In point also of size, courage, and power, the land animals in the New World are inferior to those of the Old. Especially is this the case, limiting the comparison to the southern parts of the two continents, South America and Africa.

From the splendour of the vegetation in South America, it might be inferred that the largest herbiverous quadrupeds would be found there; and only examples on a smaller scale occur in Africa, consisting of such an immense extent of naked desert, and tracts scantily clothed with low bushes and patches of grass. But the reverse of this is the case. Mr. Darwin has remarked, that taking on the African side ten of its largest animals, the elephant, hippopotamus, giraffe, bos caffer, elan, and probably five species of rhinoceros; also the same number on the American side, comprising two tapirs, three deer, the llama, vicugna, peccary, capybara, and a monkey; and it is not easy to conceive ranks more disproportionate in size, placing the two groups alongside each other. The estimated ratio as to weight of the African to the American group will be about as 6048 to 250, or as 24 to 1.

XVII. The conclusion deducible from the facts of zoological geography is parallel to that drawn from the circumstances of vegetable distribution, viz., that certain tribes of the animal creation were originally placed in particular regions, and have since remained attached to them, or to some extent been dispersed, according as their powers of locomotion, their capacity to endure change of climate, and the absence of physical obstacles to migration, have enabled them to wander.

Insects of various kinds, butterflies, moths, beetles, and grasshoppers, some in vast numbers, are often encountered far out at sea, on a voluntary cruise, or blown off from the shore; and have no doubt frequently been compelled by the winds to establish themselves in new countries. The same agency has operated in the dispersion of birds. Captain Smyth, while engaged in a survey of the Mediterranean, experienced a violent gale in the Gulf of Lyons, at a distance of from twenty to thirty leagues from the French coast, bearing along with it many land-birds of various species, which alighted on the ship, or were dashed against the sails. The oceanic currents minister to the same end, as appears from the remarkable instance of a live boa constrictor, which was quickly dispatched, reaching the island of St. Vincent, coiled round the trunk of a cedar tree, probably washed out of the bank by the floods of some South American river, while the folds of the monster encircled its branches. The white polar bear has repeatedly made the passage from Greenland to Iceland on the drifting ice; and wolves and foxes have often been met with far away from the shore on great floating ice-fields. A deficiency of food in one district, and its abundance in another, has not been without its influence in altering the station of some animal tribes.

XVIII. Man has largely contributed, voluntarily and involuntarily, to extend the sphere of various races, diffusing the domestic tribes through the civilised world, and planting them on lonely islands as a source of supply to future visitors, while some diminutive and troublesome parasites, as rats and mice, common in merchant ships, have been transferred from Europe to the remote islands of Oceanica.

Some of the Keeling islets, a group in the Indian Ocean, about six hundred miles from the coast of Sumatra, have been colonised with rats identical with the English kind, which escaped from a vessel wrecked upon the shore. At Kerguelan Island no land animal was seen by the Antarctic expedition under Sir James Ross, but the singular footsteps of a pony or ass were traced for some distance in the recently-fallen snow, supposed to have been cast on shore from some wrecked vessel.

The practice cannot be too highly commended, of introducing the plants and animals that are serviceable to man on shores that are destitute of them, but capable of sustaining them. It is an easy method of conferring a benefit of unknown importance to some unfortunate shipwrecked crew, besides providing a stock from which in ordinary circumstances ships may be provisioned. In the Auckland Isles, to the south of New Zealand, discovered by Captain Bristow in 1806, then without an animal inhabitant, he introduced some pigs, which now occur in great numbers; Sir James Ross added, at his visit in 1840, sheep, rabbits, and poultry, besides sowing and planting various kinds of edible vegetables; and recently the group, thus newly endowed with useful animal and vegetable life, has been granted by the Crown to a Company in order to become the head-quarters of the southern whale-fishery.

XIX. But man, on the other hand, has immensely restricted or modified the natural sphere of many animals, both of the useful and dangerous class. The Asiatic lion, now confined to the country beyond the Euphrates, once occupied Palestine, Syria, Asia Minor, Macedonia, and Thrace. The aurochs, of which only a remnant lingers in the Lithuanian forests, formerly roamed in numbers through the woods of Gaul and Germany. The bear, the beaver, and the wolf have had their habitat in Britain. In the time of the Romans, bears were exported from our island for the purposes of the amphitheatre; and so late as the year 1057, one of the Gordon family became celebrated for slaying a fierce individual in Scotland. The existence of the beaver in Wales comes down to the year 1158; and its presence in that principality is memorialised by the name of "Beaver Lake," given to two or three of its waters. The wolf occurred in formidable numbers in England to the year 1281; in Scotland to 1577; the last of the race being slaughtered towards the close of the seventeenth century. In the Anglo-Saxon age, the whale was characteristic of the British seas; and the number of seals on the coast of Sussex, is commemorated in the name of one of its peninsular projections, Selsey, the Isle of Seals. The presence of civilised man in North America has had a similar marked influence upon the natural boundaries of the brute creation. The bison once inhabited the Carolinas, and indeed existed through nearly the whole extent of the United States. But as the settler has pushed westward, the animal has lost part of his old domain, and chiefly occurs in force on the plains of the Missouri, or on the Pacific side of the Rocky Mountains, having only found a passage through them in recent times, along the sources of the Saskatchawan. The limits of the fur-bearing animals have undergone a similar alteration; and when from eighty to ninety thousand beaver skins, and upwards of half a million skins of the musk-rat, are annually imported into Europe, it is obvious that these races must ultimately disappear before the persevering pursuit of the hunter.

CHAPTER III.

ETHNOGRAPHY.

I. MAN is properly separated from all other members of the animal kingdom, and regarded as forming an order by himself, comprising a single species, exhibiting many varieties. The most inferior specimen of the human race is to be discriminated from any mere animal by a difference immensely greater than the change which species can be supposed to have undergone in the longest periods of time, and under the influence of the most varied circumstances. The diversities of mankind are quite compatible with the idea of their descent from a single stock, for they are precisely diversities of the same nature with those which we know arise in species, under control of external causes.

Linnæus placed man in the order of *quadrumana*, four-handed; but the human hands and feet are totally different in structure, and fitted for different uses. The hand of man is also so far superior to that of the quadrumanous tribes, in its mechanism and adaptations, as to render their classification together inappropriate. Accordingly, Cuvier constitutes of man the single order of *bimana*, for he alone is two-handed. The characteristics of the species, as given by Blumenbach, are:—"Erect, two-handed, unarmed, rational, endowed with speech; a prominent chin; four incisor teeth above and below; all the teeth equally approximated; the canine teeth of the same length as the others; the lower incisors erect."

II. Owing mainly to the flexibility of his constitution, although obtaining much artificial aid, man can subsist under the greatest climatic extremes. The Esquimaux endure the cold between the parallels of 70° and 80°; the African negroes subsist under the burning sun of the Equator; while Europeans, accustomed to an intermediate temperature, have borne the rigour of the highest accessible latitude, and the fiercest heat of the Torrid Zone.

The power of the human frame to resist cold, according to Sir John Ross, who experienced four successive Arctic winters, appears to vary remarkably in different constitutions. His general conclusion is, that the ruddy, elastic, florid, or clear-complexioned man, endowed with what physicians call the sanguine temperament, has a peculiar power of retaining heat; while those having pale, flabby, and sallow countenances, whose temperament is said to be phlegmatic or melancholic, are proportionably deficient. The most ample clothing will not compensate for the deficiency, since it can only retain the internal heat; and if this be wanting, one might as well attempt to "warm a piece of ice by means of a blanket." He places his chief reliance on abundance of food; and it is well known that the Esquimaux take as much as ten and twelve pounds weight of animal food in twenty-four hours, its effect being heightened by the fat and oleaginous quality of their diet. The oxygen which is inhaled with atmospheric air, combines chemically with the carbon of the food, and that chemical action is the cause of heat and vital force. Therefore, a much larger supply of animal food, which contains many times more carbon than vegetables, is necessary in a cold climate; while, amid torrid heat, rice and fruit form an appropriate diet.

III. The human frame can also adapt itself to very different states of the atmosphere as to density, though with a varying capacity in different individuals. The Andean valleys and table-lands, varying 10,000 feet in elevation, where the barometric column stands at 30 inches in the one, and at only 20 on the other, have their respective inhabitants. The French geometers, Bougier and Condamine, while measuring in that region an arc of the meridian, occupied for three weeks a station at the height of 14,000 French feet above the level of the sea. The barometer stood at $15\frac{3}{4}$ inches, the atmospheric pressure being therefore very little more than half that to which they had been accustomed.

The experience of travellers, from the rarity of the air at great heights, is very various. Some have suffered no inconvenience, while others have been painfully affected; this has no doubt arisen from constitutional differences; but "the difficult air of the iced mountain's top" appears to lose all difficulty to those who have had some acquaintance with it. Professor Forbes felt nothing peculiar on the Jungfrau, at 12,870 feet; but he had been living for weeks at the height of 8000 feet. Mr. Darwin, who experienced painful respiration on crossing the Portillo pass of the Chilian Andes, intimates that, at Potosi, about 13,000 feet above the sea, though strangers suffer at first from the atmosphere, no inconvenience is felt after a short stay. Dr. Le Pileur, with MM. Brevais and Martins, ascended Mont Blanc in August, 1844. They suffered most during the first hour after their arrival at the summit of the mountain; in the second hour, they felt better, and after that suffered very little; but they had no appetite during the whole of the time that they were at a height above 4000 yards.

IV. The human race are not confined to any particular kind of food, but subsist in different situations with equal facility on very varied diet. Vegetables are the chief aliment of the nations within the tropics; animals, of the polar tribes; both sources, with no great disproportion, contributing to support the inhabitants of temperate climates. Man is thus adapted for a very wide geographical range, and fitted to occupy physically discordant regions. In high latitudes, where a mantle of snow covers the ground through the greater portion of the year, and vegetation is very scanty, entire hordes live on fish and seals; towards the equator, where vegetation flourishes most, vast numbers thrive with no other articles of support than cocoa-nuts, bananas, yams, and rice; in the intermediate districts, the special region of the cerealia, and where animal food can as readily be procured, a mixed diet obtains.

An attempt has been made to classify mankind according to particular kinds of food, as follows:—1. *Carnivorous*, flesh-eaters; 2. *Ichthyophagists*, fish-eaters; 3. *Frugivorous*, fruit and corn-eaters; 4. *Acridophagists*, locust-eaters—some wandering Arabs; 5. *Geophagists*, earth-eaters—the Otomacs on the banks of the Orinoco; 6. *Anthropophagists*, man-eaters; 7. *Omnivorous*, devourers of everything. But the only classification that can be made with respect to food, is the very general one already noticed, referring to the inhabitants of polar, temperate, and equatorial regions.

V. Few countries of the globe have been discovered without an indigenous human population. Among the principal are Spitzbergen, Nova Zembla, Iceland, Madeira, St. Helena, the Falkland Isles, Kerguelen's Land, the Antarctic Lands, and the African Sahara, excepting its oases. Respecting the aggregate number of individuals, the estimates made are approximations merely, and are very discordant.

The following are the Estimates of Malte Brun and Balbi:

	Malte Brun.	Balbi.
Population of Europe	170,000,000	227,700,000
" Asia	320,000,000	390,000,000
" Africa	70,000,000	60,000,000
" America	45,000,000	39,000,000
" Oceanica	20,000,000	20,300,000
Total	625,000,000	737,000,000

The total is raised much higher by other authorities:

Europe	250,000,000
Asia, with Oceanica	550,000,000
Africa	150,000,000
America	48,000,000
Australia	2,000,000
	1,000,000,000

Probably 900,000,000 is the closest approximation.

VI. The leading physical differences observable among mankind refer to varieties of strength, stature, proportion of the limbs, texture of the skin, character of the hair, colour, and the form of the skull.

VII. Both barbarous and civilised races exhibit the diversities of physical power which are found in individual families; but, contrary to popular opinion, upon comparing the two together, the result of experiment shows

"The stoic of the woods, the man without a tear,"

to be inferior to the civilised man in muscular energy and capacity of endurance, though some of his bodily powers and senses, the eye and ear, are remarkably vigorous.

During a voyage to Australia, M. Peron obtained with the dynamometer, an instrument contrived to exhibit the measure of strength in the arms and loins of the parties subjected to trial, results as follows:

		Manual strength. Kilogrammes.	Lumbar strength. Kilogrammes.
17	Natives of Australia	50·8	10·2
12	Natives of Van Diemen's Land	50·6	
56	Natives of the island of Timor	58·7	11·6
17	Frenchmen, attached to the Expedition	69·2	15·2
14	Englishmen of New South Wales	71·4	16·3

The first transportation of the negroes to the New World arose from the Spaniards finding the Aborigines so much weaker than themselves, as to be quite unable to endure the labour of the mines.

VIII. While members of the same nation and family exhibit considerable divergencies from the average height, there are examples of tribes departing generally from the ordinary standard as to stature. Among the natives of the New World, the Esquimaux, Nootka Sound-dwellers, Fuegians, and Peruvians, are diminutive: the Cherokees, Caribs, and Patagonians are tall. In the Old World, the Lapps and Samoides are below the standard height of Europeans; the Hottentots and Bosjesmen are far inferior to the stature of the Caffres.

M. Quetelet finds for the French the following heights:

	feet.	inches.	
Men of the greatest stature	6	8	attained by 1 in 10,000,000
Limit of the ordinary size	5	5	
Medium size	5	3	(for the English 5 feet 7½ inches)
Lowest limit of the ordinary size	5	1	
The smallest men	3	11	exhibited by 1 in 10,000,000

Among the Bosjesmen, 4½ feet is given as the average height of the men, and 4 feet of the women. The Patagonians average 6 feet, and very frequently exceed it.

Different breeds of the same animal species present a precisely similar variety. Compare the small Welsh cattle with the large-sized herds of the south of England: the Shetland ponies, with the tall-backed mares of Flanders: the bantam breed, and the large English fowls.

IX. Diversities occur with reference to the proportional size of parts of the bony skeleton, the texture of the skin and hair. Thus, examples are common in the negro tribes, of the broad, flat foot, projecting heel, "cucumber shin," and of the greater length of the fore arm, measured in proportion to the upper arm, and the height of the body. The skin is also softer and more velvety, a characteristic of some of the South Sea Islanders. The hair has, likewise, that peculiar character which has led to the African nations being styled in general "woolly-haired," fine, wiry, and crisp, while that of the Mongolian tribes is strong, straight, and scanty, and that of Europeans, soft, long, and flowing. But these characters are only variations which may be observed within the limits of any single race.

The disproportionate size of the limbs referred to, is not a constant distinctive feature, but disappears frequently from the negroes, and is found, though not so commonly, in Europeans. Some Aborigines of the Guinea coast have exhibited the utmost symmetry of form, and as such, have served the sculptor for a model.

The woolly hair, common to the negro, does not belong to several African tribes, in all other respects conformable to his type, who have the long flowing hair of Europeans; while, on the other hand, there are many Europeans, free from all negro blood, who have the crisp wiry hair denominated woolly. Scantiness of hair, usual among the Mongolian nations, is not invariable, for there are tribes, undoubtedly Mongolian, as evidenced by their physiognomy and language, with the appendage copious and bushy. Analogous variations mark the same animal species, under change of circumstances. Thus, the fine wool of the domesticated sheep is reproduced if regularly shorn; but, if the flock is suffered to run wild, as was the case with the sheep introduced into the Andean valleys, by the early Spanish settlers, the wool speedily degenerates, is succeeded by a coarser kind, finally falls off, and never reappears, the animal approximating to the Asiatic argali, covered with short fine hair.

X. Complexional differences form the most obvious of those distinctions which subsist among mankind, and have been most relied on as evidencing a descent from different original stocks. Omitting exceptional cases, there is a correspondence maintained between the colouring of the skin, eyes, and hair, which renders their mutual dependence upon the same pigmentary matter highly probable. Light hair is very generally in alliance with light blue or grey eyes; but the hue of the hair and of the skin have an analogy which is almost invariable, the fair and transparent skin, which frequently assumes a ruddy tint, being connected with light hair, and the dark-complexioned skin with black hair.

Dr. Prichard discriminates three principal varieties of the human species, according to the colour of the hair.

1. The Melanic, or black-haired variety. The corresponding hue of the skin varies from the jet black of the Senegal negroes to the very dilute shade apparent in the dark-complexioned races of Europe. The black combines with red in the copper-coloured nations of America and Africa, and with yellow in the olive-coloured tribes of Asia. The swarthy Spaniards, the southern Europeans in general, and, indeed, the great majority of mankind belong to the Melanic class, exhibiting the characteristic hue of the skin under very varying shades.

2. The Xanthous, or yellow-haired variety. The colour of the hair is light brown, auburn, yellow, or red; eyes blue or grey; complexion fair, acquiring a ruddy instead of a bronze tinge on exposure to the light and heat of the sun. The inhabitants of the temperately cold regions of Europe and Asia chiefly belong to this class.

3. The Leucous, or white variety. The colour of the hair is of a milky white, or cream tinge; that of the skin is the same, with occasionally a pinkish hue; the iris is rosy, and the pupil intensely red. The examples are not nations, but individuals, called Albinos. The instances occur in all countries, but are, perhaps, most common in hot climates.

XI. Various considerations decisively show that the distinctions of colour exhibited by the human race are perfectly independent of diversity of origin as the cause, and have sprung up in the species under the influence of purely local circumstances. The colour is not a permanent character. Thus we find the Xanthous variety making its appearance in Melanic tribes, of which a number of examples might be cited. This occurs even among the most swarthy, as the negroes of Senegal. The Jews furnish a remarkable instance: while the Jews long settled in Malabar and Cochin-China are so black as not to be distinguishable by complexion from the native inhabitants; more recent settlers, not yet darkened by the climate, are styled White Jews, and the ordinary Jewish complexion, in Poland and Germany, is florid, with blue eyes and red hair.

1. Nations whose common origin is evidenced by the fundamental conformity of their language, and who, though now far apart, are led back by history and tradition to the same site, display every variety of shade exhibited by the human race in general. The Japetic, or Indo-European group of nations, extending from the Ganges to our own shores, and the Semitic, or Syro-Arabian tribes, stretching from Western Asia along the Mediterranean coast of Africa, are variously deep black, swarthy, and fair.

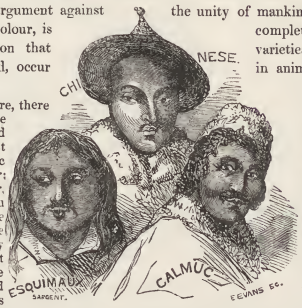
2. Various tribes, bound together by the closest affinities of language, and general bodily configuration, occupying a very limited area of country, present very diverse shades. Thus, in Northern Africa, between its Atlantic and Mediterranean shores on the one hand, and the Sahara on the other, is a country varying in physical character, level and mountainous, the native inhabitants of which speak dialects of the ancient Berber language, and are very differently complexioned. The Tuarick tribes, bordering on the Desert, are nearly as black as the darkest negroes; the Kabyles of Algiers and Tunis occupying the hills which form the lesser Atlas, are swarthy; while the lofty table-land of the Aurès (Mons Aurasius,) is inhabited by a tribe so fair and ruddy, and with hair of so deep a yellow, that they have been supposed, though without adequate foundation, to be a colony of Teutonic origin. Among the Hindoos, also, whose territory greatly differs, from the secondary ranges of the Himalaya to the low, level plains of Bengal, the discrepancies of colour are very great,—some being actually fair, others little darker than the south Europeans, and others intensely sable. "The great difference of colour," says Bishop Heber, "between different nations struck me much; of the crowd by whom we were surrounded, some were black as negroes, others merely copper-coloured, and others little darker than the Tunisines, whom I have seen at Liverpool."

XII. Anatomical investigation proves the true skin to be similar in all nations. The pigmentary substance, upon which varieties of colour depend, is apart from it, seated in the cells of the epidermis, or scarf-skin; and our own experience shows that this colouring matter may be temporarily generated, so as to tinge in a marked manner the fairest complexion, under temporary exposure to the more direct and heating rays of the sun. Hence the "freckle" which appears in summer, and the change which we describe as becoming "tanned," or "sunburnt," manifest on those parts of the body exposed to more intense solar influence, as the face and hands; while the general frame, being covered, retains its fairness.

This is a significant intimation that variations of colour are materially influenced by different climatic states. Exposure to a burning sun has been truly recognized in the poetry of the Hebrews as one potent cause of the dark complexion: "Look not upon me, because I am black, because the sun hath looked upon me; my mother's children were angry with me; they made me the keeper of the vineyards." Shut up within the walls of seraglios, and avoiding exposure to the effect of climate, the women of many tropical countries are frequently very fair, being "bleached by artificial protection from light, or at least from the solar rays." A similar bleaching is observed to be coincident with elevation in torrid districts, where a different climatic condition subsists to that experienced in the lowlands. On the lofty table-land of Abyssinia, the inhabitants are characterised by light complexions, though in the same geographical latitude as the negro races. The same remark applies to the Arabs on the highlands of Yemen, who have often blue eyes, red hair, and light complexions; while those of the low countries about the Nile are almost jet black. In the valley of the Jordan, where intense heat is almost invariable, Mr. Buckingham noticed that the Arabs had darker skins than he had seen elsewhere. In fact, the black, dark brown, and copper colours, prevail in equatorial districts; the lighter olive is distinctive generally of the nations immediately without the tropics; and still lighter shades become more universal in the higher latitudes; showing the intimate connection of colour with climate.

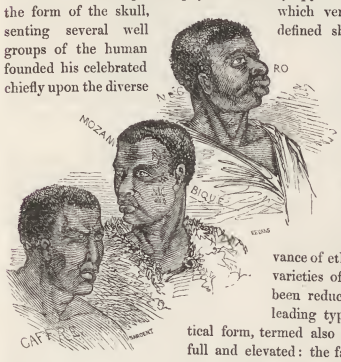
ORGANIC LIFE:—CONFORMATION OF THE CRANIUM IN MAN.

XIII. The argument against the unity of mankind, founded upon differences of colour, is completely exploded by the consideration that varieties of hue, quite as strongly marked, occur in animals of the same species.



"In the Mysore, there are three varieties of sheep; they are of colour in the white; and these red, black, and breeds. The ass are not distinct presents singular of the Carnatic some are of the varieties of colour; while others are usual ash-colour, which case the almost black, in shoulders disap- cross on the asses are also to be pears: milk-white are rare. These found, but they species, for black are not distinct sometimes ash- individuals have *vice versâ*. Some coloured colts and are mentioned by remarkable facts Azara, with reference to the colour of horses and oxen in Paraguay. It is well known that both of these races have run wild in South America, and the climate being congenial to them, have multiplied prodigiously in the fertile plains in the neighbourhood of the River de la Plata. Azara says that all the wild horses are of a chesnut, or bay-brown colour, while the tame horses are of all colours, as in other countries; hence he conjectures this to be the original colour of the race. He makes a parallel observation respecting the ox." Varieties in the colours of animals sometimes spring up casually and sporadically; in other instances, they are generally prevalent in particular breeds. In the different parts of England, Wales, and Scotland, there are different breeds of cattle and of horses. In some districts the oxen are always black; in others, brown or spotted. The cattle of particular countries are immediately recognized by their colour. Blumenbach has noticed many examples of the same kind. He remarks that all the swine of Piedmont are black; those of Normandy, white; and those of Bavaria, of a reddish brown colour. The same author observes that the oxen of Hungary are of a greyish white; in Franconia, they are red. Horses and dogs are spotted in Corsica: the turkeys of Normandy are black; those of Hanover almost all white. In Guinea, the dogs and the gallinaceous fowls are as black as the human inhabitants of the same country."

XIV. The last important physical diversity apparent among mankind refers to the form of the skull, which very remarkably varies, presenting several well predefined shapes, distinctive of great groups of the human population. Blumenbach founded his celebrated classification of mankind chiefly upon the diverse conformation of the cranium. The division is into five varieties:—the Caucasian, Mongolian, Malay, Ethiopian, and American. But this classification, though still often retained, has been rendered largely inapplicable by the advance of ethnographic knowledge. The varieties of cranial conformation have been reduced by Dr. Prichard to three leading types. 1. The oval or elliptical form, termed also symmetrical: the forehead full and elevated: the face small, and distinguished by the regularity and evenness of the features.



2. The narrow and elongated form, suggesting the idea of compression at the two sides, called prognathous, because of its distinctive character being acquired by the forward prominence of the jaws, which gives a peculiarly ferocious and animal character to the countenance. 3. The broad or pyramidal form, which

derives its peculiar character from the great lateral prominence of the cheek bones, and the rapid narrowing of the forehead at its highest part.

The oval form corresponds to the Caucasian of Blumenbach; but, together with the features which belong to it, is probably displayed in its greatest perfection by the Greeks. It characterises all the Indo-Atlantic nations, spread over the countries between the Excalaya mountains and the Indian Ocean, and extending from thence, with a few exceptions, to the Atlantic shores of North-western Africa and Western Europe.

The prognathous form corresponds to the Ethiopian of Blumenbach, but is most distinctive of the Guinea-coast negroes. It is, however, scarcely discernible in many African nations to whom it has been assigned as a type.

The pyramidal form corresponds to the Mongolian of Blumenbach, but peculiarly distinguishes the Esquimaux.

XV. But while there are certain great groups of nations exhibiting differences of cranial conformation, each variety appears with widely different degrees of development in its respective group, and entire tribes, or families, supply evidence of craniological change, which harmonises the unity of the species with the fact of its diversity. It is probable that the numerous distinctions between civilization and barbarism, with great climatic contrasts, originate mainly the structural differences observable in the human race. Near a thousand years ago, the Magyars, a race of northern Asiatics, were expelled from their native region, and exchanged a rigorous for a more genial climate, by planting themselves in Hungary, abandoning at the same time their nomadic habits for a settled mode of life; and in the interval of ten centuries, their cranial configuration has undergone a change from the pyramidal to the elliptical, and they are not now recognisable from regular Europeans. A similar alteration has been observed in the case of many negroes associated with the whites in the West Indies and America, without there having been any intermixture of race.

The lower animals descended from a common stock, present analogous structural differences, which especially distinguish the domesticated breeds from their congeners running wild. Thus, in the most highly disciplined variety of canines, the spaniel, the skull departs more widely from the form distinctive of the wolf, than that of the mastiff, a less cultivated animal. Blumenbach asserts, that there is less difference in the form of the skull in the most dissimilar of mankind, than between the elongated head of the Neapolitan horse and the cranium of the Hungarian breed. That physiologist was the first particularly to describe the remarkable variations of structure presented by breeds of swine. It is certain that they all descend from the wild boar; and equally certain, that they were unknown in America till conveyed there by Europeans; but in the short interval that has elapsed since their introduction, they have degenerated into races very different from each other, and from their original. The domestic swine in general, vary from the wild boar, as to the form of the skull, quite as much as the whole difference between a negro and an European.

XVI. While the physical differences of mankind are not only consistent with the anatomical phenomena exhibited by known species, their unity is strongly confirmed by a common conformity to the same physiological laws. There is a wide distinction between man and the animals that make the nearest approach to him, in point of longevity, the extreme term of the orang-outangs being estimated at not more than thirty years; but the capacity for long life is not greater in one tribe of the human race than in another, nor is there any difference as to its average duration under equal circumstances as to climate, food, clothing, habitation, and the sanitary aids which civilisation furnishes.

The limit of the civilised man's existence in the most favourable circumstances very

rarely extends to one century, though most European nations supply a few instances of that boundary being exceeded. In Belgium, on January 1, 1831, there were sixteen centenarians, the three oldest individuals being 104, 110, and 111 years. Occasional examples of greater longevity also occur; but they are not confined to Europeans, or to whites, for negroes have been known to attain an age equal to it. Of the native Americans, Humboldt states, that it is by no means uncommon to see at Mexico, in the temperate zone, which is half-way up the Cordillera, natives, and especially women, reach a hundred years of age: this old age is generally comfortable, for the Mexican and Peruvian Indians preserve their strength to the last. He mentions the case of an Indian woman near Lima, who at the age of 143, went a distance of from three to four leagues daily on foot. Of the Australian aborigines, Captain Grey remarks, that with regard to the age occasionally attained by them, very erroneous ideas have been prevalent, for so far from being short-lived, they frequently attain the age of seventy and upwards. Mr. Eyre speaks of having met with many venerable white-headed men among them, who could not have been less than eighty, retaining the full vigour of mind, and the bold, upright, though wasted form, that had characterised them in the pride of manhood. That the average duration of life should be much inferior among the barbarous races, as compared with the civilised, is adequately explained by a precarious mode of life, physical hardships, ignorance of remedies in sickness, and of the habits favourable or adverse to vitality.

XVII. The same general coincidence prevails with reference to other physiological characters, as the age of puberty, the period of gestation, the signs of advancing life, and the diseases to which the human frame is subject, the greater part of which are common to all communities, modified by differing climates and local position.

XVIII. As far as the Psychical properties of the different nations of mankind have been examined, or those intellectual and moral capabilities in which humanity properly consists, the differences are not greater between the races of men than those which appear within the limits of the same race. Examples are not wanting within our own shores, of individuals apparently shorn of the high prerogatives of their kind, sunk in stolid ignorance, and abandoned to brutal habits, having grown up apart from the means of cultivation; and the case of entire tribes, as the Bushmen of South Africa, and the Fuegians of South America is but a parallel one, deriving its more melancholy features simply from a more complete destitution of improving influences. This may be inferred from the recovery from extreme barbarism exemplified by tribes whose nature has been fairly tested by intellectual, moral, and religious education.

XIX. The result of modern philological inquiry has been to reduce the languages of the great bulk of mankind, the inhabitants of the old continent, to a few great groups, and traces of community are observed in these groups, which indicate a derivation from a common stock.

In referring different languages to a common family their grammatical affinity is the criterion, not their lexicographical agreement. The languages of the Old World are classed by Chevalier Bunsen into the following families:

1. The Indo-European, called also the Japetic, likewise the Iranian, comprising the Sanscrit, Medo-Persic, Teutonic, Græco-Latin, Sclavonic and Celtic branches, with their derivative dialects.
2. The Syro-Arabian, styled also the Semitic, comprising the Aramæan or Syriac, Hebrew, Arabic, and Ethiopic, with their derivative dialects.
3. The Turanian, called also Ugro-Tartarian, including the languages of High Asia, of some inhabitants of Northern Europe, the Lapps and Finns, and probably of the Basques in Spain.
4. The Chinese and Indo-Chinese, or the monosyllabic and uninflected languages.
5. The African languages spoken by the woolly-haired nations within a few degrees north of the equator, and all south of that line.

The Japetic and Semitic groups are considered as one in essential character. The Semitic tongues, which belong to nations who have remained stationary in semi-civilisation, stop short with a tendency towards that system of inflections, characteristic of a progressive people, which the Japetic generally develops, and most highly in its Hellenic branch. The Turanian family of languages, spoken by most of the nations of Asia, exhibits vestiges of original connection with the Japetic; the Malayo-Polynesian languages are through the Malayan connected with the Turanian group; and the further prosecution of Chinese philology will probably bring to light indications of relationship to the same stock. It is, however, a striking fact, that where the philological discordance among nations is at its maximum, the anatomical difference is at its minimum, and *vice versâ*. Thus, while the distinction between the Chinese and the other languages of Central and Northern Asia is very marked, their physical conformity to those nations is just as decided. All information, at present scanty, respecting the languages of Central and Southern Africa, tends to prove, that they have sprung from a single stem referable to the common stock of the preceding branches.

The languages of the aborigines of the New World are very numerous, and exhibit the very singular phenomenon of great lexicographical discordance, amounting in some instances to having not so much as a single word in common; yet from Cape Horn to the Arctic Ocean, they are all connected by the same principle of formation and grammatical structure, analogous to that of the Turanian tongues of Asia.

According to Adelung there are 3664 known languages and dialects in the world, distributed as follows:

European	587	American	1624
Asiatic	937	Oceanic	240
African	276		

Modern experience teaches us, that the speech of a nation, maintaining its geographical site and political status, changes remarkably in a short space of time from purely domestic causes. New words are required in the progress of society, and old ones become obsolete. The English of Chaucer and Wickliffe is unintelligible to the general reader; that of Spenser is scarcely less obscure; and a glossary is a common appendage to Shakespeare.

But this modification of the vocabulary forms no case parallel to the phenomenon presented by different languages. Yet as, notwithstanding their variations, the English, German, Dutch, Danish, and Icelandic, are branches from the Teutonic stem; as we certainly know, with greater divergences, that the Teutonic, Celtic, Sclavonic, Græco-Latin, Zend, and Sanscrit, constitute a single family, the Indo-European, having been developed from a common original at a remote era; there is no difficulty in conceiving of the great linguistic families, with still wider divergences, the Indo-European, Semitic, Turanian, &c., having originated from a common source, at a still remoter period; and in the more primitive ages of the world, when mankind, few in numbers, dispersed themselves in detached bodies, losing all traces of each other, making varied progress, and encountering different experiences, it is easy to understand, that the diversifying process with reference to language would be proportionably active.

XX. It may be concluded, therefore, with rigorous certainty that no specific difference exists among mankind, but an immense number of varieties. It is impossible to account for their occurrence otherwise than in a very superficial manner. The causes will probably ever remain enveloped in mystery, along with those of similar variations in single families, and analogous phenomena in the animal kingdom. Owing to varieties existing with very unequal degrees of development, one passing gradually into another, no accurate classification of the species can be made according to characteristic differences. An approximation to such an arrangement is all that can be done, and is given in the Ethnographic map.

1. The Iranian nations. 2. The Turanian nations. 3. Negroes. 4. Hottentots and Bushmen. 5. Oceanic Negroes and Alfourous. 6. Native Americans.

XXI. The Iranian nations correspond to the Caucasian of Blumenbach, and the West Asiatic of other writers. The name is derived from Iran, the ancient and proper appellation of the great plateau of modern Persia, included between the rivers Tigris and Oxus. The class comprises nearly all the Asiatics within a line extending generally from the mouth of the Ganges, along the Himalaya mountains, the course of the Oxus, intersecting the Caspian Sea, and following the chain of the Caucasus to the Euxine; also all the North Africans above latitude 20°; almost all the inhabitants of Europe; and, of course, the European colonists settled in various parts of the globe. This vast section of the human family comprehends at present, and has ever done, since the date of authentic history, the most perfectly formed, vigorous, and intellectual of mankind. The Egyptians, Hindoos, Assyrians, Babylonians, Medo-Persians, Greeks, Romans, and Arabs, successively represented the civilisation of by-gone times, founded mighty monarchies, and obtained paramount influence in the world, a heritage which has descended to the western Europeans, and the offshoot from them in the United States.

Owing to India and the Atlantic Ocean being geographical boundaries of the Iranic nations, they are frequently styled Indo-Atlantic. Their bond of union is a common physical conformation, which may be generally stated as follows: Large cranium, beautifully shaped small head, oval face, expanded forehead, small mouth, regular features, and symmetrical shape: hair, fine and copious; colour not a characteristic, since the complexion is of all shades, fair and florid, olive, swarthy, and jet black. The configuration appears most perfectly developed in the Greeks, ancient Persians, and some others: least so in the ancient Celts.

In Europe, the non-Iranic races are the Tschudic tribes of the north, Finns and Lapps; the Magyars; the Turks; and, perhaps, the Basques.

Complete obscurity rests upon the early peopling of Europe, but as far as history throws light upon the remote past, it seems to have received great waves of Iranian races in the following order of historical succession: 1. The Celtic race, occupying the western and south-western parts of Europe, while the Tschuds possessed the northern and north-eastern, and various tribes of unknown origin were scattered over the south-eastern. The latter, crossed by the Celts, and fresh Asiatic immigrants, originated the Greeks, a mixed race; and the fusion of the native tribes of Italy, with Celts and Grecian immigrants, originated the Latins, a race still more mixed. The Greeks, Italians, French, Spanish, Portuguese, Irish, Gaelish, Welsh, Manx, and Cornish, belong to this branch. 2. The Teutonic race entered Europe at a later period, driving the Tschuds farther north, and the Celts farther west. The Scandinavian branch of this family settled in Norway, Sweden, and Denmark, occupied the adjacent islands, extended themselves to Britain, and finally spread to Iceland. The Germanic branch took possession of Germany, Holland, parts of Switzerland, Schleswick, and contributed a leading element to the population of Britain. 3. The Sclavonic race came into Europe at a date still later, occupying the principal part of Russia, Lithuania, Poland, Bohemia, Moravia, and the provinces on the Danube. The Celtic, Teutonic, and Sclavonic races have been variously mixed, but have remained also to a considerable extent comparatively pure.

XXII. The Turanian nations correspond to the Mongolian and Malayan of Blumenbach. The denomination is derived from Turan, the Persian name ap-

plied to the wild and extensive plains of Tartary, and all the countries of Asia beyond the Oxus, as distinguished from the table-land of Iran. But nations apart from these geographical limits are included in this division. The principal are as follows: 1. In Asia, the Tungusian, Mongolian, Turkish, Thibetian, Chinese, and Indo-Chinese races, with the Hyperborean tribes spread along the inclement shores of the Arctic Ocean, as the Samoiedes, Tschuktschi, Kamschatkans, and Aleutian islanders, chiefly ichthyophagi, or fish-eaters. 2. In Oceanica, the Malayo-Polynesians, scattered through various groups of the Pacific, exhibiting wide diversities, but supposed to have sprung from an Indo-Chinese germ. 3. In Europe, the Turks, Magyars, and Tschudic races; the latter extending from Lapland and the White Sea, along the Ural Mountains to the borders of the Caspian. 4. In America, the Esquimaux, and other related tribes, closely resembling the Hyperboreans of the Old World.

These nations are characterised generally by the pyramidal form of the skull; a peculiarity derived from the great lateral prominence of the cheek-bones, and the rapid narrowing of the forehead at its highest part. The face is larger in proportion to the size of the skull than in Europeans, and round instead of oval. The eyes are small, deep, and obliquely set; hair scanty; complexion, a sallow or yellow olive; stature, commonly below the European standard. But many tribes depart widely from one or more of these characters, while conformable to the rest. The Samoiedes, Tungusians, and other northern Asiatics have a dirty brown or swarthy colour; the Mantchoo-Tartars in China, and some of the Chinese themselves, approximate to a fair and even florid complexion; and various tribes have the hair and beard long and bushy.

In Europe, the Turks, a settled race, have become widely different from the nomadic Turkish clans of central Asia, corresponding to the physical character of the great bulk of the Europeans. The same correspondence is also observable among the Magyars of the higher class, while the mass of the people retain the conformation of their ancestors, with some modification. The Lapps, Finns, and other Tschudic races of north-eastern Europe, exhibit very decidedly the characters of the Turanian division of mankind.

Dr. Kombst gives the following summary of the population of Europe:

Total of	Teutonic blood, pure and mixed	82,000,000
„	Celtic blood (including the Græco-Latins)	68,700,000
„	Sclavonian blood, pure and mixed	58,000,000
„	Finnian and Samoiedian tribes	3,000,000
„	Lettons, Lithuanians, and Kures, mixed Finnian and Sclavonian	2,000,000
„	Turks	4,000,000
„	Magyars	9,000,000
„	Tartars, in the south and south-eastern provinces of Russia	4,600,000
„	Kalmyks, betweeen the Volga and Ural	300,000
„	Jews, spread over Europe generally	2,000,000
„	Gypsies, ditto	600,000
		234,200,000

XXIII. The Negro nations occupy Africa from the parallel of 20° north latitude to the borders of the Cape Colony; and have been largely planted in the West Indies and United States by forcible transportation.

The peculiar physiognomy of the Negro—skull compressed laterally, and forward prominence of the jaws; low, narrow, and slanting forehead; large eyes, thick lips, and prominent cheek-bones; woolly or crisp hair; black complexion—is most apparent in the natives of the Guinea Coast. Many tribes diverge remarkably in conformation and colour. High foreheads, light brown complexion, and reddish hair, are frequently met with among the Kafirs, though there is no reason to doubt their connection with the proper Negro races.

XXIV. The Hottentots and Bushmen, the latter a degraded caste of the former, inhabit the high table-land of Southern Africa, and the basin of the Orange River. Though usually classed with the Negroes, they are very discordant from their type, having the skull decidedly pyramidal, with obliquely set eyes, yellowish complexion, spare hair, and other characters strikingly according with those of the Central and Northern Asiatics.

XXV. The Oceanic Negroes, resembling the African in various features, and the Alfourous, are islanders of the Indian and Pacific Oceans, forming tribes either associated with the Malayo-Polynesians, or entirely separate.

They comprise, 1. The Negroes of the Indian Seas,—races of puny stature, woolly hair, black or nearly so, with features strongly akin to those of the Guinea Coast natives; found in the Andaman Isles, Bay of Bengal; in Lasso, Luzon, and others of the Philippines. 2. The Papuas, inhabiting New Guinea, the islands and archipelagoes around Australia, of puny stature and sooty hue, distinguished by their bushy frizzled hair growing on the head in separate tufts, described on that account by Dampier, as the "mop-headed Papuas." 3. The Alfourous or Araforas, found in New Guinea, with whom are classed all the natives of Australia, very darkly tinged like the Oceanic Negroes, constitute a variety distinct from them and the Malayo-Polynesians, by decided physical differences.

XXVI. The American nations, excluding the Esquimaux, and the descendants of European and African colonists, are intimately related to each other, so as to form a single family; the last of the great divisions of mankind, divergent in various respects from the groups of the Old World. Though commonly styled the red or copper-coloured race, the cinnamon hue is not universal, some tribes being nearly black, others brown or yellow, and others comparatively fair.

XXVII. The specific identity of mankind by no means solves the problem of their origin—whether they have all sprung from a single pair, or whether duplicates, triplicates, or other multiples of pairs were brought into being in different regions, formed so much alike that there should be no specific difference between them. Some eminent writers conceive that the latter alternative may be held, the two first inhabitants of Eden being regarded as the progenitors only of the race from whence sprung the Hebrew family, in harmony with the announcements of the Scriptures. But the theory appears to be antecedently improbable, and it is quite unnecessary to explain the phenomena of the dispersion of the species. Mankind have not, like plants and animals, a constitution adapted simply to particular geographical localities; and there is no great difficulty connected with the idea of their diffusion from the location of a single pair. The New World might readily receive inhabitants from the Old, across the narrow strait which separates them; and likewise by the chain of the Japan, Kurile, and Aleutian archipelagoes, a series of stepping-stones extending from China to the north-west coast. Canoes, diverted by winds and currents from their course, have borne their occupants into perpetual exile, and contributed to stock remote islets of the ocean with a human population.

BRITISH ISLANDS AND SURROUNDING SEAS.

CHAPTER I.

ASTRONOMICAL AND GEOGRAPHICAL POSITION.

The British Archipelago, consisting of Great Britain, Ireland, and numerous adjuncts, is situated between 49° 52′ and 60° 49′ N. lat.; and between 1° 46′ E. and 10° 40′ W. long. The Channel Islands, which geographically belong to France, are not included in these limits; nor Rockall, a very small and solitary granite rock in the North Atlantic, upwards of 250 miles from the north coast of Ireland, and 180 miles from the most westerly of the Western Isles of Scotland, the nearest point of land. Herma Ness, in Unst, one of the Shetlands, forms the northern extremity, and the Scilly Islands the southern. Lowestoft Ness, on the coast of Suffolk, is the eastern confine, and the Blasquet Isles, off Dunmore Head in Kerry, the western. The archipelago lies off the north-west coast of Europe, from which it is separated by the North Sea or German Ocean, the Strait of Dover, and the English Channel. The opposite portions of the continent are the north of France, the Netherlands, Denmark, and the south of Norway.

Between the extreme eastern and western points, there is a difference of 12° 26′ of longitude, or nearly 50 minutes of time; and owing to the range of latitude amounting to 10° 57′, the sun is above the horizon at the summer solstice about 2 hours 40 minutes longer in the north than in the south. The length of the longest day, independent of refraction, is about 18 hours 48 minutes in the northern extremity, and 16 hours 8 minutes in the southern. This great length of the days at the summer solstice in the north, together with the nights consisting of brief intervals of bright twilight when the sky is cloudless, originated the impression current with the ancients that in the highest latitudes of the British Isles the sun did not set for 24 hours at midsummer. Pytheas of Marseilles, a Greek navigator, who visited Thule, supposed to be the Shetlands, probably in the fourth century before Christ, reported this physical exaggeration, which, nearly five centuries later, was reproduced in the pages of Tacitus: "In the farthest part of Britain," he states, "the nights are so clear that you can hardly tell when daylight begins or ends; and when the sky is not overcast with clouds, you may see all night long the light of the sun, which does not rise or go down, but moves quite round,"—a phenomenon only exhibited at and within the Arctic Circle.

Great Britain, the largest island of Europe, extends through 8° 43′ of latitude, from the parallel of the Lizard in Cornwall, 49° 57′, to that of Dunnet Head, 58° 40′, the north extremity of Scotland; and through 7° 54′ of longitude, from the meridian of Lowestoft Ness, 1° 46′ E., to that of Ardnamurchan Point in Argyleshire, 6° 8′ W., which stretches somewhat farther west than the Land's End of England. It makes the nearest approach to the continent at the south-east angle, where the Kentish shore at Folkestone is not more than 20 miles from the French coast at Cape Grisnez. The former union of the two countries by an isthmus, wasted by the denuding force of the seas on either hand, is intimated by the comparative shallowness of the intervening strait, the proximity and identity in composition of the opposite cliffs and shores, whether flat and sandy or steep and chalky, and the occurrence of a submarine ridge running across the Channel. Northwards from this point of contiguity, the British coast has a general direction N.W., and the continental N.E., the two therefore mutually receding, a distance of 400 miles subsisting between Scotland and Denmark. The following places of the opposite shores have about the same latitude:

British.	Continental.
Ramsgate	Ostend.
Harwich	Rotterdam.
North coast of Norfolk	South extremity of the Texel.
Mouth of the Humber	Mouth of the Weser.
Scarborough	Heligoland.
Northumberland	South Jutland.
Aberdeenshire	North Jutland.
Mouth of the Dornoch Firth	The Naze of Norway.
Duncansby Head	Stavanger.

In the contrary direction, the British coast trends W. by S., and the continental S.W., consequently retreating from each other, but in a less degree than in the preceding instance, their greatest distance being about 140 miles, from St. Alban's Head, in Dorsetshire, to St. Malo, in Brittany.

Ireland, to the west of Great Britain, is separated from it by the Irish Sea, the St. George's and North Channels. It comprises nearly 4° of latitude, from Brow Head in Cork to Malin Head in Donegal; and 5° of longitude, from the east of County Down to Cape Sybil in Kerry. The north extremity corresponds in latitude to that of the Coquet River at its mouth in Northumberland, and the south point to that of Bristol. It approaches nearest to Great Britain in the north-east, where Fair Head in Antrim is only 13½ miles from the Mull of Cantire in Argyleshire. In the south-east, the distance is about 50 miles between the nearest projections, Greenore Point in Wexford, and St. David's Head in Wales.

The smaller portions of the archipelago are very unequally distributed. They are prolongations of the western and northern extremities of the two main masses, excepting the Isle of Wight, off the south coast of England, and a few islets of unimportant extent. The Scilly group, 140 in number including mere rocks, is evidently a detached extension of the south-west angular projection of England. Anglesea and Holyhead are close adjuncts of the mainland of Wales. The Isle of Man, by its configuration and the direction of its high land, from N.E. to S.W., indicates itself to be a continuation of the adjacent Scottish coast. The Isles of the Firth of Clyde and the Inner Hebrides, are prolongations of the western mainland of Scotland, of which the Outer Hebrides form a more distant detachment; the Flannan Islands, with St. Kilda, being remote outliers of the latter group. The three clusters comprise upwards of 200 members, of which about 80 only are inhabited. Northwards the main mass of Britain is prolonged by the Orkneys, 67 in number, with 29 inhabited; and by the more outlying Shetlands, consisting of upwards of 100, with 32 inhabited. The islands connected with Ireland are principally western or north and south-western prolongations of the mainland, in most instances very little detached, amounting to nearly 200, of which between 130 and 140 are inhabited.

CHAPTER II.

LINEAR EXTENT AND AREA.

No straight line can be drawn due north and south intersecting the whole of Great Britain, owing to its general inclination N.W. The meridian of 2° W., which cuts the centre of England from the Dorset coast to Berwick upon Tweed, scarcely touches Scotland at all. The greatest direct linear extent of the surface is from S.E. to N.W., stretching from Rye in Sussex to Cape Wrath in Sutherlandshire, measuring about 580 miles; and the next longest straight line, cutting no portion of the sea, extends from S.W. to N.E., or from the Land's End to Winterton Ness on the Norfolk coast, including 367 miles. Disregarding inlets of the sea, and considering the island as forming a rude triangle, with Dunnet Head for the apex, the North Foreland and Land's End being the extremities of the base, the following are the direct measurements from point to point:

	Miles.
From Dunnet Head to the North Foreland	540
From Dunnet Head to the Land's End	600
From the Land's End to the North Foreland	320

Due east and west, the greatest breadth occurs near the parallel of 52°, between St. David's Head in Pembrokeshire and the Naze in Essex, the distance being about 280 miles. But the deep indentations of the sea remarkably contract the space between the opposite coasts at various points, and almost insulates the north extremity of Scotland.

BRITISH ISLANDS:—SEAS AND COASTS.

	Miles.
Distance between the outlet of the Avon in the Bristol Channel, and London, near the head of the estuary of the Thames	116
Between the N.E. extremity of Cardigan Bay, near Harlech, and Fossdyke Wash in the Wash	170
Between the estuary of the Mersey at Liverpool, and Hull on that of the Humber	113
Between the estuary of the Ken at the Head of Morcambe Bay, and Saltholme on the estuary of the Tees	70
Between the outlets of the Esk and Eden in the Solway Firth, and the outlets of the Blyth and Wansbeck in Northumberland	62
Between Dumbarton on the Clyde, and Alloa on the Forth	33
Between Fort William at the head of Loch Linnhe, and Inverness near the outlet of Loch Ness into the Murray Firth	55
Between the head of Loch Broom, and Kincardine on the Firth of Dornoch	24
Between the ascent of the tide in the Oikel, a river of the Dornoch Firth, and the west coast	18

Estimates of the circuit of the island are founded more upon probable calculation than actual survey. The deep and narrow inlets which mark the configuration of the N.W. side render it exceedingly difficult to arrive at a tolerably exact approximation. In the annexed measurements, the direct distances between the more prominent points of the shores occasionally cut through portions of intervening land, while the sinuosities of the coast are only followed up the broad parts of the estuaries and inlets.

	Direct Distance. Miles.	Distance following the Coast. Miles.
From Cape Wrath, N.W. extremity of Scotland, to		
Duncansby Head, N.E. extremity	72	108
Tarbet Ness, between the Dornoch and Murray Firths	57	90
Kinnaird's Head, Aberdeenshire	64	117
Fife Ness, Fife-shire	100	128
North Sunderland Point, Northumberland	63	137
Flamborough Head, Yorkshire	115	138
Winterton Ness, Norfolk	122	216
South Foreland, Kent	107	184
Beachy Head, Sussex	56	68
Lizard Point, Cornwall	245	344
Land's End, ditto	23	36
Bull Point, Devonshire	103	132
Worm's Head, Glamorganshire	23	178
St. David's Head, Pembrokeshire	51	104
Carnal's Point, Anglesea	114	214
Rock Perch, Mouth of the Mersey	65	82
St. Bee's Head, Cumberland	78	122
Mull of Galloway, Wigtonshire	53	147
Mull of Cantire, Argyleshire	61	170
Ardnamurchan Point, ditto	93	122
Rue Rea, Ross-shire	85	125
Cape Wrath	51	150
Total	1801	3112

The circuit, as determined by the penetration of the sea, or the true salt-water coast-line, has a far greater extent than the preceding estimate, and the line of tidal influence is vastly in excess of it. For example, the estuary of the Thames is measured up to the Nore Light, but the salt-water line extends above Gravesend, and the tide is felt as far as Teddington, nearly 19 miles above London Bridge.

Ireland rudely resembles an oblique parallelogram in its general form, having the longer sides nearly in the direction of the meridian, the shorter inclining from N.E. to S.W. Its greatest extent, due north and south, without cutting the sea, coincides with the meridian of 8° W., and embraces 234 miles, from Ballycotton Flagstaff in Cork to Horn Head in Donegal. But a diagonal line stretching from Mizen Head in Cork N.E. to Fair Head in Antrim measures about 300 miles. The greatest breadth in the direction of a parallel intersecting no arm of the ocean, includes about 175 miles, from Achris Point in Galway to the coast between Dublin and Drogheda. Dublin and Galway Bays are not however more than 108 miles apart; and from Ballyshannon Harbour S.E. to the head of Dundalk Bay the width is only 85 miles. The direct circuit of the island is estimated at 750 miles, but following the coast-line along the estuaries and inlets, it will include nearly three times that extent.

The area of the entire British archipelago can only be stated approximately, owing to complete surveys being wanting; but the total of the annexed Table is probably as exact as any that have been given:

	Square Miles.
England	50,387
Wales	7,425
Isle of Man	235
Scilly Islands	9
Scotland	26,014
Firth of Clyde Islands	165
Inner and Outer Hebrides	2,739
Orkneys	440
Shetlands	880
Ireland	32,513
Total	120,807

The area of Ireland is accurately known from the Ordnance Survey, completed with reference to that country, and nearly so in the case of South Britain, also in process of execution in North Britain. The districts most open to doubt are the west and north of Scotland, and the Scottish Islands.

CHAPTER III.

SEAS AND COASTS.

The North Sea, forming a kind of Mediterranean or close sea between the east of Great Britain and the continent, extends from the Strait of Dover, lat. 51° N., to a line which joins the northernmost of the Shetlands with the coast of Norway at the Sogne Fiord, near lat. 61° N. From south to north it comprises a linear extent of 690 miles, by 405 miles from east to west, where the greatest expansion occurs, about the parallel of 56°, between St. Abb's Head on the Berwickshire coast, and the Ringkiobing Fiord on the Danish shore. Its area is computed at 244,000 square miles. The greatest depth is on the Norwegian side, where the soundings give from 100 to 290 fathoms; but the mean depth of the whole is stated by Mr. Stevenson to be only about 31 fathoms. Notwithstanding the irregularity of the depth from the occurrence of numerous sandbanks, it increases upon the whole as we proceed from south to north. A longitudinal section coinciding with the meridian of 3° E., which intersects the centre, gives the following results:

	Fathoms.
Central depth in the lat. of Yarmouth	18
Flamborough Head	24
Tynemouth	17
North Berwick	40
Tarbet Ness	50
Lerwick	90
61°	120

Transverse sections, taken at various points, show that from west to east the depth varies considerably; but that, as a general conclusion, there is a greater depth of water on the west and east sides, except close in shore, than in the central parts; and that on the whole the water is deeper on the British than on the continental shores, the coast of Norway excepted. Great accumulations of debris occupy the bed of the sea. The Dogger Bank, which is subdivided by the navigator into the Long Bank, the White Bank, and the Well Bank, occurs in the centre, extending upwards of 300 miles from north to south. Another great bank, known to mariners as the Long Forties, stretches upwards of 110 miles N.E. from the mouth of the Firth of Forth. A considerable number, of inferior dimensions, lie between the entrance of the Humber and the South Foreland, among which the Goodwin Sands have acquired an unhappy notoriety for the numerous shipwrecks of which they have been the scene. These sands, about 10 miles long by from 3 to 4 broad, divided into two parts by a narrow channel navigable for small boats, lie off the Kentish shore between the North and South Foreland, and form a kind of breakwater, protecting on the east the roadstead of the Downs. Altogether, from a vast number of observations and comparisons, Mr. Stevenson estimates the average height of the sandbanks of the North Sea at about 78 feet, their superficial extent at upwards of 27,400 square miles, and their solid contents at no less than 2,241,248,563,110 cubic yards,—equal to 28 feet of the whole of Great Britain in perpendicular height or depth, supposing its surface to be a level plane.

The British part of the coast-line is marked with several considerable inlets,—

the estuaries of the Thames, the rivers of the Wash, and the Humber, with the firths of Forth, Tay, Murray, and Dornoch. It presents also prominent projections, the most extensive being the angular district terminating at Kinnaird's Head in Scotland, and the rounded protuberance formed by the most easterly counties of England. But generally the coast is far more regular than on the west of the island. South of Flamborough Head the shores have for the most part a tame appearance, consisting of low cliffs of clay or chalk, flat marshy lands, and sand-hills or sandy levels; but northwards from that promontory a bold and rocky character predominates. Great changes have occurred within the date of authentic history, the sea gaining upon the coast at various points, and the coast gaining upon the sea at others. A submarine forest, which has been traced for several miles along the northern shore of the county of Fife, and another, visible as far as the limits of low water on the low shore of Lincolnshire, memorialize the former existence there of dry land; while a spacious estuary, which extended as far as Norwich in the Saxon times, has been silted up, and converted into a cultivable region.

The English Channel, separating Great Britain and France, extends from the Strait of Dover to a line connecting the Land's End and the island of Ushant, a distance somewhat exceeding 300 miles. Westward from the narrow strait, the Channel rapidly expands to 90 miles from Brighton to Havre, contracting to scarcely 70 between St. Catherine's Point on the Isle of Wight and Cape Barfleur, but opening to upwards of 110 miles at its junction with the Atlantic. The area is estimated at 282,000 square miles. The shallowest part follows a line drawn between Romney Marsh and Boulogne, but from thence the depth progressively increases towards the Atlantic, so that the western entrance of the Dover Strait may be regarded as a point of partition between the two great inclined planes forming the bottom of the Channel and the North Sea. The depth is greater on the British than on the French side, and the ports and harbours are superior. Eastward the coast presents a tolerably smooth line; but westward from Selsey Bill it pursues a very sinuous course, forming the inlets of Portsmouth Harbour, Southampton Water, Studland Bay, and Weymouth Harbour, with the three broad openings of West Bay, Plymouth Bay, and Mounts Bay, each comprising repeated indentations. Hurst Castle shingle bar and the Chesil bank are remarkable features of this shore. The shingle bar is a low tongue of land, projecting from the Hampshire coast towards the Isle of Wight, narrowing the intervening channel of the Solent, with Hurst Castle on its extremity. It consists of rounded chalk flints, with other pebbles intermixed, derived from the waste of cliffs to the westward, forming a causeway about a mile long, 12 feet high, and about 70 yards broad. The Chesil bank is a still more extraordinary formation. It connects the so-called Isle of Portland with the mainland of Dorset, and extends about 10 miles in length, the breadth amounting in some places to a quarter of a mile, and the height to 20 feet above high-water mark. This immense barrier, entirely composed of rounded loose pebbles resting on hard blue clay, is one of the most remarkable shingle ridges in Europe.

The Irish Sea, with St. George's and the North Channels, between Great Britain and Ireland, extends from a line joining Carnsore Point with St. David's Head on the south, to a line connecting Fair Head with the Mull of Cantire on the north, and includes an area estimated at 22,900 square miles. Its bed on the side of Ireland is largely encumbered with shifting sands, bars, and sunk rocks; and sandbanks render the navigation intricate on the British side towards the estuary of the Mersey. The two coast-lines remarkably differ. Few inlets of importance occur on the Irish shore, while the opposite shore of Wales has the deep indentation of Cardigan Bay, and the most extensive inlet of the sea exhibited in the British Islands is formed between North Wales and South Scotland.

The Atlantic, from the south-west of England, round the greater part of Ireland, and the west and north of Scotland, to the Shetlands, supplies a magnificent seaboard, the rugged and torn aspect of the shores exposed to its huge breakers proclaiming their force. The coasts are generally bold, rocky, and precipitous, largely consisting of long narrow peninsulas, formed by the denuding action of the waves upon the more yielding materials. A remarkable physical feature of the Atlantic in the neighbourhood of the British archipelago is the sudden and great depression of its bed from 100 to 200 fathoms and upwards, indicated by dotted lines upon the map.

PROMINENT HEADLANDS AND SOME REMARKABLE POINTS OF THE COASTS.

The asterisks denote the sites of Lighthouses.

1. *England and Wales.*	Height in feet.
Bamborough Castle, Northumberland, on a perpendicular rock of basalt	150
Hartlepool Point, Durham, N. of Tees estuary, a mass of magnesian limestone	40
Flamborough Head,* Yorkshire, chalk cliffs, lantern of the lighthouse	214
Spurn Head,* ditto, sandbank, N. entrance of the Humber.	
Boston Church, Lincolnshire, lantern seen at sea upwards of 40 miles	300
Hunstanton Cliff,* Norfolk, chalk and red sandstone	120
Cromer,* ditto, chalk cliffs rapidly wearing away	250
Lowestoft Ness,* Suffolk, low tract of sand, the most easterly land of Great Britain.	
The Naze, Essex, clay cliffs, N. boundary of Thames' mouth	100
Nore floating-light vessel, about 3 miles N.E. of Sheerness.	
Greenwich Observatory, Kent	214
North Foreland,* ditto, chalk cliffs, S. boundary of Thames' mouth and of the Port of London	280
South Foreland,* ditto. chalk range abounding with samphire	400
Dover Castle Hill, ditto	469
Swingfield Church steeple, ditto, N.W. of Dover	530
Folkestone turnpike, ditto	575
Dungeness,* Sussex, low point terminating Romney Marsh.	
Beachy Head,* ditto, bold perpendicular chalk cliff	564
Dunmore Head, Isle of Wight, S.E. point	792
St. Catherine's Point, ditto, S. extremity.	
The Needles,* ditto, W. extremity	469
St. Alban's Head, Dorsetshire, bold promontory of oolitic limestone	344
Portland Bill,* ditto, terminating the high freestone mass of Portland peninsula	30
Bolt Head, Devonshire	430
Plymouth Breakwater, ditto, 1700 yards long, protecting Plymouth Sound.	
Eddystone Lighthouse, 9 miles off shore in Plymouth Bay, top of the lantern	85
Deadman Point, Cornwall	379
The Lizard,* ditto, S. point of Great Britain, composed of serpentine	224
St. Michael's Mount, ditto, a granitic rock opposite Marazion, insulated at high-water	231
Land's End, ditto, granite cliffs	100
Cape Cornwall, ditto, granitic headland	229
Trevose Head, ditto	274
St. Agnes,* the most southern of the Scilly Isles that is inhabited, lantern of the lighthouse	138
Hartland Point, Devonshire, N. coast.	
Village of Linton, ditto	428
Lundy Island,* a granite mass in the Bristol Channel, highest point	200
St. Anne's Head,* Pembrokeshire, N.W. boundary of Milford Haven	235
St. David's Head, ditto, N. boundary of St. Bride's Bay.	
Aberystwith Castle rock, Cardiganshire	496
Penmaen-Mawr, Caernarvonshire, coast between Bangor and Conway	1540
Great Orme's Head, ditto, a limestone mass off the mouth of the Conway	673
South Stack,* Anglesea, west extremity of Holyhead peninsula	201
Point of Air,* Flintshire, N. extremity of the mainland of Wales.	
St. Bee's Head,* Cumberland, new red sandstone rock	222
2. *Scotland.*	
St. Abb's Head, Berwickshire, station of the Preventive mast	286
Bass Rock, Firth of Forth, a precipitous mass of granular greenstone	400
Bell Rock,* a ledge off the Firth of Tay, covered at high-water, lantern of the lighthouse	115
Buchan Ness,* Aberdeenshire, the most easterly land of Scotland	130
Tarbet Ness,* Ross-shire	175
Duncansby Head, Caithness, N.E. point of Great Britain, a mass of confused red sandstone strata,—the foundation of John o' Groat's House about 1½ mile W.	
Dunnet Head,* ditto, N. extremity of Great Britain, lantern of the lighthouse	346
Cape Wrath,* Sutherlandshire, N.W. headland of Great Britain, of perforated gneiss	600
Point Ardnamurchan, Argyleshire, the most westerly land of Great Britain.	
Garroch Head, Firth of Clyde	750
Mull of Galloway,* Wigtonshire, S. point of Scotland, lantern of the lighthouse	325
3. *Ireland.*	
Hill of Howth,* Dublin, N. entrance of the Bay	549
Fair Head,* Antrim, N.E. point of Ireland, a mass of rude basaltic columns	626
Bengore Head, ditto, a basaltic rock beautifully columnar	400
Giant's Causeway, ditto, a basaltic promontory upwards of 1000 feet long at low-water.	
Malin Head, Donegal, the most northerly land of Ireland.	
Horn Head, ditto	921
Glen Head cliffs, ditto, N. of Rossan Point	750
Slieveleague cliffs, ditto, south of Rossan Point	1965
Achill Head, Achill Island, Mayo, cliffs to the northward	1800
Loop Head,* Clare, N. point of the Shannon estuary.	
Dunmore Head, Kerry, N. entrance of Dingle Bay.	
Cape Clear,* Cork, S. promontory of Clear Island, and of the Irish coasts.	
Bray Head, Wicklow	807

The tides that are propagated in the British seas from the great diurnal undulations of the Atlantic receive very different directions from the varying configuration of the shores, and rise high in general, owing to being crowded into comparatively confined spaces. A wave of high water reaches the archipelago between three and four hours after the moon has passed the meridian, its ridge extending N.W. from off Brest Harbour on the coast of France to a little to the south of Cape Clear in Ireland. This wave soon afterwards is divided into three: one part passing up the Channel through the Dover Strait into the North Sea; a second entering the Bristol Channel, and through St. George's into the Irish Sea; and a third ranging along the west side of Ireland and Scotland. The latter travels with the greatest velocity, being in a more open sea. After rounding the Orkneys and Shetlands, it pursues a perfectly inverted course, from north to south, descending into the North Sea, and forms a ridge extending from Buchan Ness on the east of Scotland to the Naze of Norway, by the time that the Channel tide-wave is off the mouth of the Thames. On the west and north of Scotland the islet groups cause various minor divergencies, and produce tidal currents flowing from all points of the compass, —whirlpools and agitated waters resulting from the meeting of opposite streams, of which the Roust of Sumburgh is an example, denominated from Sumburgh Head, the south promontory of the Shetlands, the word *roust*, of Scandinavian origin, being used to signify a tumultuous current occasioned by the collision of rapid tides. The Channel wave chiefly carries high water to the coasts of the Netherlands and Germany, and has very slight influence on the opposite shores of England, owing to their obliquity to its direction; while the great northern wave determines high water along the east side of Great Britain and at London, by its superior intensity. High water at the London Docks, say on a Tuesday afternoon, is the dying undulation of a flood produced on Sunday morning in the South Pacific by the attraction of the celestial luminaries, the intermediate time having been occupied in marching over the surface of the ocean from the place of its genesis. A few *establishments*, or the time of high water at new and full moon, are as follows:

TIME OF HIGH WATER WHEN THE MOON PASSES THE MERIDIAN AT TWELVE O'CLOCK, HER PARALLAX BEING 57′, AND HER DECLINATION 15°.

	H.	M.
Brest Harbour	3	48
Plymouth Dockyard	5	33
Portsmouth Dockyard	11	40
Ramsgate Harbour	11	46
Sheerness	0	39
London Docks	1	57
Bristol Cumberland Gates	7	15
Pembroke Dockyard	6	4
Liverpool Docks	11	22
Howth Harbour	11	8

On Boston Deeps, in the Wash, spring tides rise 23 feet; at Chatham, 18; London bridge, 19; Spurn Head, 23; Hull, 22; Newhaven, 20; Exmouth, 18; Milford Haven, 28; outside the Bristol Channel, 24; King's Road, at the mouth of the Bristol Avon, 48; and at Chepstow on the Wye the rise is sometimes 60 feet. In the Solway Firth the tide comes in with great rapidity, with a rise of 4 or 5 feet of water abreast, constituting a bore. The tide also rushes into the Severn with a head 4 or 5 feet high; and at springs there is a very strong bore in the Trent, the water rising on the surface at its mouth to the height of six or eight feet, and rolling on in a large mass up the river.

CHAPTER IV.

GENERAL OROGRAPHIC SURVEY.

South Britain, according to the aspect of the surface, may be considered as consisting of two principal divisions, possessing a definite and distinct physiognomy,—a generally rugged and occasionally mountainous tract on the north-west, west, and south-west; and a district of gentle elevations intermingled with plains, much more extensive, embracing the eastern, central, and southern counties. They may be conveniently styled Highland and Lowland Regions.

The Highland Region extends, though with several interruptions, along the western side from the Scottish border to the Land's End, approaching the east coast in the north, and running out towards the centre of the kingdom in the hills of Derbyshire and Staffordshire. It comprises the Pennine Chain, the Cumbrian, Cambrian, and Devonian or South-western Mountain Systems, with detached ridges and eminences.

Pennine Chain.—This chain traverses northern England in the line of its length from north to south. It stretches from Carter Fell, one of the Cheviots, near the sources of the Upper Tyne on the frontier of Scotland, lat. 55° 18′ N., to the Weaver Hills on the east border of Staffordshire, lat. 52° 50′ N., comprising an entire course of about 170 miles. A depression intersected by the Newcastle and Carlisle Railway, near to which is the line of the old Roman wall, and the valleys in which the Eden, Tees, Lune, Ribble, and affluents of the Yorkshire Ouse, have their upper courses, interrupt its continuity. The chain, low and narrow at its north extremity, attains its greatest elevation near the junction of Cumberland, Westmoreland, and Durham, acquires considerable expansion in Yorkshire, and continues broad and high to the Derbyshire Peak. Mountain limestone, largely cavernous, is the characteristic rock, composing the great masses of Cross Fell, Ingleborough, Wharnside and Pennigant. Millstone grit, extensively developed, forms the surface of elevated moorlands covered with heathy vegetation, and is occasionally seen capping isolated limestone summits, projecting in remarkably bold escarpments.

Projection of Millstone Grit, on the top of Stonnis, Derbyshire.

	Feet.
Village of Glenwhilt, Northumberland, near the Roman wall, and the summit level of the Newcastle and Carlisle Railway	446
Allenheads, ditto, highest habitation in England	1400
Killhope Head, Durham, near the chief source of the Wear	2196
Collier Law, ditto, between the Upper Wear and Derwent	1678
Pontop Pike, ditto, on Lanchester Common, S.E. of the Derwent	1018
Mount Brandon, ditto, 3 miles S.W. of Durham	875
Cross Fell, Cumberland, 11 miles S.S.E. of Penrith, culminating point of the Pennine Chain, and highest limestone mountain in Great Britain. The South Tyne and Tees rise from a swamp on the east slope. From the summit the Irish and North Seas may be seen in fine weather. Snow remains long, and has continued unmelted through the summer. A spring of very clear cold water occurs near the top	2901
Water Craig, Yorkshire, E. of Richmond, near the source of the Swale	2180
Shunnor Fell, ditto, ditto	2329
Wharnside, ditto, 9 miles N.E. of Kirkby Lonsdale, and 13 miles N.N.W. of Settle	2385
Ingleborough, ditto, 8 miles N.W. by N. of Settle, 30 miles round the base	2361
Pennigant, ditto, 6 miles N. by E. of Settle, divided from Ingleborough by Ribblesdale	2270
Town of Settle, ditto	621
Bradfield Moor, ditto, N.W. of Sheffield	1246
Summit level of the Huddersfield Canal, ditto, in Marsden Tunnel, highest canal in the kingdom	656
Bleasdale Forest, Lancashire, 13 miles N. by E. of Preston	1709
Boulsworth Hill, ditto, 8 miles E.N.E. of Burnley	1689
Rivington Pike, ditto, 5 miles N.W. by W. of Bolton	1545
Holme Moss, at the junction of Cheshire, Yorkshire, and Derbyshire, crossed by the turnpike-road from Huddersfield to Stockport, at a greater elevation than any road south of it in England	1859

	Feet.
Hathersage Hill, Derbyshire, 8 miles W. by S. of Sheffield	1377
Lord's Seat, ditto, near Hathersage, on the Yorkshire border	1751
Mam Tor, ditto, near Castleton, 12 miles N.E. of Buxton	1709
Kinderscout, ditto, 11 miles N. by E. of Buxton, highest point of the Peak	1981
Axe Edge, ditto, near Buxton	1873
Combe Moss, ditto, 2 miles from Buxton, crossed by the road to Manchester	1500
Sir William, ditto, near Eyam	1418
Chelmorton Church, ditto	1218
Teddington Church, ditto	1122
Elton Church, ditto	1117
Summit level of Cromford and High Peak Railway	1290
Weaver Hill, Staffordshire	1155
Moorlands connected with the Pennine Chain in Northumberland, Durham, west Yorkshire, east Lancashire, and north Stafford, not marked by any striking inequalities of surface, but elevated from	500—1000

In the East Riding of Yorkshire there is an extensive tract of high lands completely detached from the offsets of the Pennine Chain by the valley of the Ouse and its tributaries. It is divided into two principal portions by the valley of the Derwent, extending east and west, the northern portion forming the Egton or North York Moors, and the southern the Yorkshire Wolds. The former district has a general elevation of 1000 feet, but rises in Black Hambleton Down to 1246 feet; Loosehoe Hill, 1404 feet; and Button Head, 1485 feet. The Wolds are considerably lower, Wilton Beacon, 12 miles E. by N. from York, the highest point, being only 809 feet.

Cumbrian System.—This group forms a continuous mass of high land with the preceding chain, but its geological constitution is quite distinct; and while its direction is nearly at a right angle with that of the Pennine Range, it acquires a character superior to that of a lateral offset by its great elevation. The two, therefore, though frequently classed together under the denomination of the Northern Range of England, are more properly separated. The narrow valley through which the Eden descends from its source to Kirkby Stephen, in lat. 54° 25′, about the parallel of Richmond, Yorkshire, may be regarded as the eastern limit of the Cumbrian or Lake Mountains, which extend from thence, variously expanding, nearly due west towards the Irish Sea, terminating at Dent Hill near Egremont, a few miles from the coast. They stretch from east to west about 35 miles, by 37 miles from north to south, where the group has its greatest expansion. and are estimated to occupy more than a third of Cumberland, about a fifth of Westmoreland, and a small part of north Lancashire. Varieties of slate constitute the main masses, intersected by dykes of trap, and associated with granite, sienite, greenstone, and other primitive rocks.

Skiddaw Mountains.

	Feet.
Nine Standards, Westmoreland, 13 miles S.E. of Appleby	2136
Langdale Pikes, ditto	2400
Grassmere Fell, ditto, 16 miles N.W. of Kendal	2756
Helvellyn, ditto	3055
Red Tarn, on Helvellyn	2400
Coniston Fell, Lancashire, 8 miles N. of Ulverstone	2577
High Pike, Cumberland, 8 miles N.N.E. of Keswick	2101
Saddleback, ditto, 5 miles N.E. of Keswick	2787
Pillar, ditto, 9 miles S.W. by S. of Keswick	2893
Bow Fell, ditto, 10 miles S. of Keswick	2911
Skiddaw, ditto, 5 miles N.E. of Keswick	3022
Scaw Fell, ditto, 11 miles S. by W. of Keswick	3092
Scaw Fell Pikes, higher summit, culminating point of the group and of England, a mass of gray slate, crowned with trap porphyry. Though higher than Cross Fell, the winter's snow remains longer upon the latter, owing to its more inland situation	3166
Dent Hill, ditto, last of the slate mountains towards the Irish Sea	1115
Highest point of the road between Kendal and Shap	1187

The Cumbrian Group and Pennine Chain inclose the extensive plain of north Cumberland, near the centre of which is Carlisle. The tide sometimes ascends the Eden to within four miles of the city; the water is salt to within five miles of it; and the coast is so low above Maryport that a very slight rise of the sea would send its waters to the foot of the mountains, and change the Solway Firth into a great gulf.

Cambrian System.—Wales, the most truly Alpine district of South Britain, has almost its whole surface occupied by ranges of mountains, which, while really distinct, have such a close general connection as properly to be classed together in one group; and the ridges and heights of the English counties bordering on the principality, may be viewed as detached offsets of the Cambrian System. The principal chains are Snowdonia, the loftiest, in the north-west, chiefly occupying Caernarvonshire; the Berwyn range, extending from near the mouth of the Dovey in Cardigan Bay N.W. to the junction of the three counties of Denbigh, Salop, and Cheshire; the Plynlimmon range, stretching from the mountain of that name along the south side of the valley of the Upper Severn into Salop; and the range of South Wales, running nearly due east and west between the Usk and Towy rivers, parts of which are styled the Black Mountains from the dark appearance of the heather when out of blossom. These chains have many offsets, and high moorland tracts occur apart from them. Coal strata occupy an extensive area in South Wales; the mountain limestone appears in the north-east; the old red sandstone occurs in force in the south-east and south; but slates and sandstones of the Silurian series are the characteristic formations, associated to some extent with porphyritic and other trappean rocks. The hills of south Salop, and the Malvern Hills, which divide Herefordshire from Worcestershire, are outlying portions of the mountain system of Wales. The Malverns form a beautiful ridge, extending about eight miles, but everywhere narrow, swelling into many distinct summits, principally composed of sienite.

BRITISH ISLANDS:—GENERAL OROGRAPHIC SURVEY.

	Feet.
Snowdon Range.—Penmaen-Mawr, Caernarvonshire, on the coast	1540
Bwlch-Mawr, ditto, S.E. of Clynnog	1673
Reivel, ditto, ditto	1886
Shiavod, ditto, near the inn at Capel Cerig	2878
Caern-y-David, ditto } E. of Caernarvon, near the source of the {	3427
Caern-y-Llewellyn, ditto { Ogwen	3469
Snowdon, ditto, 10 miles S.E. of Caernarvon, culminating point of South Britain, with three summits of nearly equal height, the most elevated of which is called the Wyddra, or "the conspicuous summit"	3571
Craig Drwg	2100
Craig-y-Car } Offsets in the N.W. of Merionethshire, extending {	2147
The Cnicht } from Snowdon southwards to the River Maw, {	2272
The Moelwyn } forming one of the boldest parts of the princi- {	2372
Rhinog-Fach } pality	2400
Rhinog-Fawr	2463
Berwyn Range.—Cader-Idris, Merionethshire, 5 miles S.W. of Dolgelly	2914
Arrenig, ditto, 10 miles N. by E. of Dolgelly	2809
Arran-Fowdy, ditto, 8 miles S.S.W. of Bala	2955
Cader-Ferwyn, ditto, 7 miles E. of Bala	2563
Plynlimmon Range.—Plynlimmon, border of Cardiganshire and Montgomeryshire, source of the Severn and Wye	2463
Llandinam, Montgomeryshire, 2 miles N.E of Llanidloes	1898
Longmynd, Long Mount Forest, Salop, S.W.	1674
Breddon Hills, boundary of Salop and } Summit with Rodney's Monument	999
Montgomeryshire } Moel-y-Goba	1199
Range of South Wales, called in the Ordnance Maps, Forest Fawr—	
Cradle Mountains, Brecknockshire, 6 miles N.E. of Brecon	2545
Capellante Mount, ditto, 8 miles S.W. of Brecon	2394
Brecknockshire Beacons, two summits, 4 miles S.W. of Brecon	2862
Caermarthenshire Beacons, borders of Caermarthen and Brecknock	2596
Sugar Loaf, Monmouthshire, N. of Abergavenny	1760
Pen-y-Cader Fawr, ditto	2545
Outliers of Salop.—The Wrekin, 8 miles E.S.E. of Shrewsbury	1320
Clee Hills, N. by E. of Ludlow	1806
Malvern Hills.—Midsummer Hill, near the S. extremity, earthworks of an ancient camp	1006
Hereford Beacon, near Little Malvern, ancient camp works	1162
High Point, near Malvern Wells	1224
North Hill, N. extremity of the range	1366
Worcester Beacon, Great Malvern, near the N. extremity, highest point, visible from Bardon Hill in Leicestershire	1444

The mountains of Wales are not continuous with those of the north of England, but separated by an extensive plain which comprehends the south-west of Lancashire, great part of Cheshire, and north Salop. They are divided also from the next group by the valley of the Severn and its estuary.

Devonian or South-western System.—The angular projection of England terminating at the Land's End, only assumes a mountainous character at a few points, and contains no extensive definite chain, but rather consists of a series of bleak rugged heights stretching through Cornwall, connecting themselves with the grand plateau of Dartmoor in south Devon, and with the elevated mass of Exmoor in the north, which stretches into Somersetshire, prolonged by the Quantock Hills towards Bridgewater. The Black Down Hills, Mendips, and other ridges of the latter county, may be regarded as offsets; and the Cotteswold Hills of Gloucestershire as a detached outlier. Granite, with transition rocks consisting of varieties of slates, constitute the masses of Devon and Cornwall. The Black Down Hills are composed of green sand. Old red sandstone forms the nucleus and highest points of the Mendips, the mountain limestone clothing the flanks. The Cotteswold Hills are oolitic.

	Feet.
Pertinney, Cornwall, 1½ mile E. of Land's End	689
Hensbarrow Down, ditto, N.W. of St. Austell	1034
Kit Hill, ditto, near Callington	1067
Carraton Hill, ditto, N. of Liskeard	1208
Brown Willey, ditto, at the source of the Fowey river	1368
Granitic plateau, ditto, between Bodmin and Launceston	800
Harford Church, Devonshire	658
Source of the River Erme } Plateau of Dartmoor Forest, a vast mass {	1131
Two Bridges } of granite, largely covered with peat {	1148
Butterton Hill } swamps and rifted granite rocks. {	1203
Rippin Tor } Mean elevation, perhaps not less than {	1549
Cawsand Beacon } 1400 feet {	1792
Yestor {	2077
Dunkerry Beacon, Somersetshire, E. extremity of Exmoor	1668
Mendip Hills, ditto, highest point	1100
Cotswold Hills, Gloucestershire, highest point	1134

A further portion of the southern counties belongs to the South British highlands, near the junction of Wilts, Hants, and Berks, where the Inkpen Beacon attains the elevation of 1011 feet, the highest point of the chalk in Great Britain.

The remainder of the surface, from the Vale of York to the English Channel, and from the North Sea to the Welsh border, is composed, with a few exceptions, of formations more recent than the carboniferous epoch,—the new red sandstone, oolitic, wealden, and cretaceous groups, with tertiary deposits, which nowhere attain the height of a thousand feet. But an agreeable diversity marks its general aspect. The leading features consist of broad and fertile river-valleys, verdant hills, ranges of downs occasionally bold, barren, and heathy, and a large extent of comparatively level country forming the great south-eastern plain of England, comprising some marshy grounds. From Salisbury Plain, a woodless tract of table-land with an uneven billowy surface, three ridges of chalk hills diverge E. by S., E., and N.E., cut up into separate masses by transverse river-valleys, presenting rounded summits with one side steeper than the other, a characteristic of the chalk. The most southern range crosses Hampshire into Sussex, where it forms the celebrated sheep-walk of the South Downs, and terminates on the coast at Beachy Head. A second range intersects the north of Hampshire, and passes centrally through Surrey into Kent, where it is known as the North Downs, terminating on its eastern coast. From Guildford to near Farnham, this ridge bears the name of the Hog's-Back, being continuous and narrow; and southward, the lower green-sand of the chalk series occupying the surface, forms an excessively dreary district, producing only fern, heath, and furze. "In crossing this desolate region by the main road from London to Portsmouth, it is difficult to believe that we are only forty miles distant from the capital, and midway to one of the chief naval establishments of the empire; but the nature of the soil effectually prevents improvement, and it is not improbable that this tract may remain for centuries unchanged, and still exemplify the power of geological causes in modifying the civil condition of countries, as well as their external features."—*Geog. Trans.* The North and South Downs inclose in those directions the Weald of Kent, Surrey, and Sussex,—apparently, when viewed from the adjoining hills, an extensive level, though an undulating country, retaining in towering oaks monuments of its ancient forest, which in Caxton's time, who learnt his "English in the Weald," was "stored and stuffed with herds of deer and droves of hogs." A third and more important range, diverging from Salisbury Plain, follows a wavy course into Norfolk, taking the name of the Chiltern Hills in Oxfordshire, and the Gogmagog Hills in Cambridgeshire, greatly declining in height towards the eastern counties.

	Feet.
Salisbury Plain, N.W. of Salisbury, general elevation	400—500
SOUTH DOWNS.	
Butser Hill, 3 miles S.W. of Petersfield	917
Rook's Hill Beacon, 4 miles N. of Chichester	702
Chanctonbury Ring, 3½ miles W.N.W. of Bramber	814
Ditchling Beacon, 6 miles N. of Brighton	858
Firle Beacon, 5 miles S.E. by E. of Lewes	820
NORTH DOWNS.	
Highclere Beacon, near Highclere, Hants	900
Hindhead, 11 miles S.W. of Guildford	923
Leith Hill, 5 miles S.E. of Dorking, detached from the chalk	993
Botley Hill, N.E. of Reigate	880
Frant Church, 2 miles S. of Tunbridge Wells	659
Hollingsbourn Hill, 6 miles E. of Maidstone	616
NORTH-EAST RANGE.	
White Horse Hill, Berks, near Wantage	893
Scutchamfly Beacon, ditto	853
Wendover Hill, Bucks	905
Kensworth Hill, Herts	904
Royston Trigonometrical Station, ditto	484
Newmarket Station, Cambridgshire	267
Brandon, Suffolk	190
Hunstanton cliff, Norfolk	120

Other elevations in the central and eastern counties of England are Bar Beacon, N. of Birmingham, 653 feet; Castle Ring, W. of Lichfield, 715; Bardon Hill, W.N.W. of Leicester, 853; Arbury Hill, Northamptonshire, 804; Epwell Hill, near the north point of Oxfordshire, 836; and High Beech, in Essex, N.N.E. of London, 750 feet. At great distances from the sea the rivers are only at a small height above low-water mark, showing the slight elevation of the general surface: Nen, at Northampton, 198 feet; Ouse, at Buckingham, 265; Trent, at Trentbridge, near Nottingham, 73; Derwent, at Derby, 172; Trent, at its junction with the Thame, Staffordshire, 188; Avon, Northamptonshire, where it is traversed by the London and North Western Railway, 242; Thames, at Lechlade, border

of Gloucestershire, 243; Soar, at Leicester, 186; and Rea, at Birmingham, 330 feet. The greatest extent of low land lies around the estuary of the Wash, comprising portions of the counties of Lincoln, Norfolk, Cambridge, Huntingdon, and Northampton, which form the country specially styled the Fens. This district may be defined generally by a line drawn from Wainfleet on the Lincolnshire coast W. to Tattershall, running from thence S.W. to Sleaford, S. towards Huntingdon, and proceeding along the right bank of the Ouse to its mouth at Lynn. It extends north and south about 50 miles, and 30 miles east and west, where the breadth is the greatest, between Lynn and Market Deeping. The area is stated to contain 700,000 acres. Much the larger portion belongs to Lincolnshire, and includes the whole of that division of the county appropriately called Holland, *hollow* or low land, resembling in its physical features the Dutch province of that name. The great amount of land water which flows to the Wash, the very slight fall of the rivers, and the lowland character of the country, expose it to floods from sudden falls of rain, and also to inundations of the sea, requiring a network of artificial channels, with windmills and steam-power, to promote drainage, and keep the waters in check. A similar tract, mostly below high-water mark, occupies a portion of Yorkshire and Lincolnshire between the Don, Ouse, and Trent; and Romney Marsh, a low fertile plain at the south-east angle of Kent, is only prevented from being overflowed at high water by the immense embankment of Dymechurch Wall.

North Britain consists of three natural divisions,—the Southern, Central, and Northern, each containing highlands and lowlands.

The South Division of Scotland extends from the English border to the great hollow occupied by the Firths of Forth and Clyde, and the narrow plain traversed by the canal which unites the two estuaries. Its mountain system, sufficiently bold to be denominated the Southern Highlands, includes the Cheviots, on the border, with their protruding masses in Northumberland, but is principally developed in the great central nucleus of the Lowther Hills, near the junction of the counties of Dumfries, Lanark, Peebles, and Selkirk, connected by offsets with the south and east coasts. The Pentland Hills, running S.W. from the neighbourhood of Edinburgh, and the Lammermoor and Moorfoot Hills, following the same direction inland from St. Abb's Head, are detached secondary ranges. The chief lowlands are,—the basin of Ayrshire, the valley of the Clyde, the rich vale of the Haddingtonshire Tyne, the Merse of Berwickshire, the low country north of the Solway, and the pastoral straths of Nithsdale, Annandale, Eskdale, and Teviotdale.

	Feet.
Cheviot Hill, 7 miles S.W. of Wooler, highest of the Cheviots	2658
Tintoc, Lowther Hills, 7 miles S.E. of Lanark	2306
Culter Fell, ditto, 5 miles S. of Biggar	2440
Hart Fell, ditto, 5 miles N. of Moffat	2635
Whitcombe Edge, ditto, 16 miles S.S.W. of Peebles	2685
Broad-Law, ditto, 12 miles S.W. of Peebles, highest of the Lowthers, and culminating point of South Scotland	2741
Larg Fell, Kirkcudbright } S.W. and S. offsets of the Lowthers	1758
Black Larg, ditto } S.W. and S. offsets of the Lowthers	1950
Cairnsmore, ditto } S.W. and S. offsets of the Lowthers	2329
Crif Fell, ditto } S.W. and S. offsets of the Lowthers	1830
Carnethy Hill, highest Pentland	1880
Black Hope Scars, highest Moorfoot	2196
Sayers Law, highest Lammermoor	1735

The Central District of Scotland extends from the isthmus of the Forth and Clyde to the remarkable Glenmore-nan-Albin, or Great Glen of Scotland, which runs N.E. from Loch Linnhe to the Murray Firth, and is traversed by a chain of lakes connected by the line of the Caledonian Canal, uniting the Atlantic and North Sea. A vast extent of this region is occupied by mountains comprising the highest summits of the United Kingdom. The grand chain of the Central Grampians stretches across the island from the coast of Aberdeenshire, and enormous masses spread over the western side southwards, towards the estuary of the Clyde, sometimes called the Southern Grampians. Parallel to the central chain, but at some distance, an inferior range extends with interruptions from coast to coast, taking the name of the Sidlaw Hills from Montrose to Perth, the Ochil Hills from thence to the River Forth, and the Campsie Hills in Stirlingshire. Between this range and the Grampians is Strathmore, or the Great Valley, the most extensive of the Scottish lowlands. Other lowland tracts are,—the Carse of Gowrie, between the Sidlaw Hills and the estuary of the Tay; and the How of Fife, along the course of the Eden in Fifeshire.

	Feet.
Campsie Hills, highest point, N.E. of Kilsyth	1500
Ben Clach, highest of the Ochils, E. by S. of Dunblane	2359
Craig Ouh, highest of the Sidlaws, Forfarshire	1700

GRAMPIANS.

Mount Battock, W. of Kincardineshire	2800
Ben Venue, Perthshire, S. of Loch Katrine	2800
Ben Ledi, ditto, W.N.W. of Callander	2863
Ben Arthur, Argyleshire, head of Loch Long	2863
Morren Cairn, Aberdeenshire, N. of Ballater	2880
Ben Achonzie, Perthshire, N.E. of Loch Earn	3028
Ben Voirlich, ditto, S. of Loch Earn	3180
Ben Lomond, Stirlingshire, N.E. side of Loch Lomond	3195
Ben Ima, Argyleshire, E. side of Glencoe	3301
Meal Girdy, Perthshire, N.W. by N. of Killin on Loch Tay	3364
Schiehallion, ditto, E. by S. of Loch Rannoch	3513
Ben Deirg, ditto, N. of Blair Atholl	3550
Ben Uarn, Aberdeenshire, S.W. of Braemar	3589
Ben Lui, Perthshire, W. by S. of Killin	3651
Ben Cruachan, Argyleshire, N. of Loch Awe	3670
Ben y Gloe, Perthshire, N.E. of Blair Atholl	3690
Lochnagar, Aberdeenshire, S.E. of Braemar	3777
Stobinian, Perthshire, near the Braes of Balquhidder	3794
Ben More, ditto, S. of Loch Dochart	3818
Ben Lawers, ditto, N. side of Loch Tay	3945
Ben Aven, Aberdeenshire, N.W. of Braemar	3967
Source of the Dee on Mount Braeriach, ditto	4060
Cairngorm, Inverness-shire, N.W. of Ben Aven	4095
Cairntoul, Aberdeenshire, S.W. of Cairngorm	4220
Ben Macdui, ditto, N.E. of Cairntoul	4305
Ben Nevis, Inverness-shire, E. by S. of Fort William, culminating point of British Archipelago, a mass of granite at the base, the summit consisting of black porphyry. Though it does not reach the limit of perpetual snow, patches usually remain all the year round; and in a hollow fronting the north, a little below the highest point, snow always remains during the whole year. Some recent authorities raise Ben Macdui to the supremacy among British mountains, assigning to it the height of 4390 feet, or 22 feet above Ben Nevis. The point is doubtful. Ben Nevis is 1202 feet higher than Scaw Fell Pikes, 797 feet above Snowdon, and 964 feet above Carn Tual, the loftiest of the Irish mountains	4368

The North Division of Scotland, extending from the Great Glen to the Pentland Firth, has the most mountainous and barren surface, though not reaching to the elevation of the Grampians; the productive lowlands being chiefly confined to the borders of the eastern firths.

	Feet.
Ben Ormen, Sutherlandshire, S.E. of Loch Naver	2307
Ben Hae, ditto, E. of Loch More	2853
Ben Klibreck, ditto, between Loch Naver and Loch Corr	3164
Ben More Assynt, ditto, E. of Loch Assynt	3231
Ben Dearg, Ross-shire, E.S.E. of Loch Broom Head	3551
Ben Wywis, ditto, N.W. of Dingwall	3720
Ben Attow, ditto, E. by N. of Kintail	4000

The mountains in the islands of Scotland may be regarded as insular continuations of the mainland ranges, generally of moderate elevation.

WESTERN ISLES.

	Feet.
Ailsa Craig, Firth of Clyde	1097
Goat Fell, Arran	2857
Ronastil, Islay	1050
Paps of Jura, Jura	2470
Gribon Promontory, Mull	2000
Ben na Chat, ditto	2294
Ben More, ditto	3168
Oreval, Rum	1800
Ben More, ditto	2310
Scuir of Eigg, Eigg	1335
Storr Hill, Skye	2100
Ben Blaven, ditto	3000
Cuchullin, ditto	3000
Dun Can Hill, Raasay	1500
Clisseval, Lewis	2700
Swanival, ditto	2700
Hecla, South Uist	2500
Heval, North Uist	2010
Conachan, St. Kilda	1380

ORKNEY AND SHETLAND ISLES.

Ward Head, Hoy, Orkneys	1600
Saxaford, Unst, Shetlands	936
Foula Island, Shetlands	1369
Rooeness Hill, Mainland, ditto	1476

BRITISH ISLANDS:—INLAND WATERS.

In contrasting North and South Britain, the predominant highland aspect of the former, and the prevailing lowland character of the latter, are not the only points of difference. The geological composition of the surface is remarkably distinct. Granite, trappean, and other igneous rocks, occur in great force in Scotland, and very sparingly south of the border. Metamorphic masses, gneiss, and mica-slate, comprise nearly half the surface of Scotland; while, excepting unimportant examples in Cumberland, there is hardly any real gneiss or mica-slate in England and Wales. On the other hand, the formations more recent than the carboniferous epoch, which in England cover about two-thirds of the country, are in Scotland only represented by a few detached patches of oolite, of wholly insignificant extent.

Ireland has its general physiognomy determined by a great central plain, extending across the island from Dublin to Galway Bay, and from the county of Fermanagh on the north to the borders of Waterford on the south. This great tract is far from being a dead level, but diversified with hills and valleys, though its most elevated point, Moat-a-grenogue, in Westmeath, is little more than 300 feet above the level of the sea. A large proportion of its area is occupied with flat red bogs, denominated from their reddish tinge, consisting of decomposed vegetable matter, covered with unproductive living vegetation, holding more or less stagnant water. Imposing highlands occur external to the plain, or on the borders, throwing out spurs into it; but the mountain masses constitute detached ranges, and groups of limited extent, and not a continuous belt, though largely cutting off the low country from the coasts.

	Feet.
Slievedonard, Mourne Mountains, S. coast of Down	2796
Eagle Mountain, ditto, N.E. of Carlingford Bay	2084
Slievegallion, Carntogher Mountains, Londonderry	1730
Slievesawell, ditto, S.E. of Londonderry	2236
Slieveleague, Mountains of Donegal, S.E. of Rossan Point	1965
Slievenaght, ditto, W. by N. of Lough Foyle	2019
Bluestack, ditto, N.E. of Donegal Bay	2213
Erigal, ditto, S.E. of Bloody Foreland Point	2462
Slievemore, Mountains of Mayo, N.W. coast of Achill Island	2184
Mount Croghan, ditto, W. coast of Achill Island	2250
Croaghpatrick, ditto, S. of Clew Bay	2499
Nephin, ditto, W. side of Loch Conn	2639
Mulrea, ditto, coast of Killery Head	2680
Twelve Pins, Galway, N.W. of Killerran Bay	2396
Knockline, Mountains of Kerry, N. entrance of Kenmare River	2160
The Paps, ditto, E. by S. of Killarney	2280
Mangerton, Mountains of Kerry, S.E. of Killarney	2754
Slievenish, ditto, S.W. of Tralee	2799
Mount Brandon, ditto, N. coast of Dingle Peninsula	3120
Carn Tual, or Macgillicuddy Reeks, ditto, W. of the Lakes of Killarney, culminating point of Ireland	3404
Mount Gabriel, Mountains of Cork, N. coast of Bantry Bay	2335
Hungry Hill, ditto, N.E. of Mizen Head	2248
Knockmeledown Mountains, Waterford, S.W. of Clonmell	2700
Keeper Mountains, Tipperary, W. of Thurles	2265
Galtee Mountains, ditto, W. of Cahir	3000

CHAPTER V.

INLAND WATERS.

RIVERS.—The surface of Great Britain comprises six hydrographical regions, defined by the water-parting between rivers flowing off in opposite directions, and proceeding to different basins, or communicating at distant points with the same basin. These systems of drainage may be respectively denominated:—the Eastern, by far the most important, consisting of the entire east of England and Scotland, with a large portion of the central districts, connected with the German Ocean; the Southern, embracing the counties, in whole or in part, which border the English Channel; the South-Western, extending from north Northamptonshire to the Severn estuary, and including the principal part of Wales, with the country on both sides of the Bristol Channel to the Land's End and St. David's Head; the Western, comprising the west of Wales, the north of the principality, and those parts of England and Scotland which are contiguous to the Irish Sea; the North-Western, embracing the west of Scotland, communicating its waters to the Atlantic; and the Northern, an insignificant portion of the north extremity of Scotland, sending off a few streams in an opposite direction, northward, to the same basin. Ireland has four similar hydrographical regions; an eastern system of drainage, the least important, belonging to the Irish Sea; the remainder of the surface sloping northward and southward, but principally westward, to the Atlantic.

Referring the rivers of the United Kingdom to their respective basins, the following systems are indicated:

RIVER-SYSTEM OF THE EASTERN BASIN OR GERMAN OCEAN.

RIVERS.	SOURCE.	AFFLUENTS.	COUNTIES DRAINED IN WHOLE OR IN PART.
Greater Stour	N. of Hythe, Kent	Lesser Stour	E. Kent.
Medway	N. border of Sussex	Eden, Teise, Beult	N. Sussex, S.E. Surrey, Kent.
Thames	Thames Head, 1½ miles N. of Kemble, Wilts	Coln, Windrush, Evenlode, Cherwell, Kennet, Loddon, Wey, Mole, Brent, Lea, Roding, Darent	N. Wilts, E. Gloucester, Berks, Oxford, Buckingham, N. Hants, Surrey, Middlesex, Herts, W. Kent, Essex.
Blackwater or Pant	S.E. of Saffron Walden	Brain, Chelmer	Essex.
Coln	N.E. of Sampford on the Pant	Roman	Essex.
Stour	S.E. corner of Cambridgeshire	Bexford, Bret	Cambridge, Essex, Suffolk.
Orwell or Gipping	N. of Stowmarket		Suffolk.
Yare	S. of East Dereham	Wensum, Waveney	N. Suffolk, Norfolk.
Great Ouse	N.W. of Brackley, Northamptonshire	Tow, Ivel, Cam, Lark, Little Ouse, Stoke, Nar	S. Northampton, N. Buckingham, Bedford, Huntingdon, Cambridge, W. Suffolk, W. Norfolk.
Nen	Naseby, Northamptonshire	Ise	Northampton. N. Huntingdon, N. Cambridge.
Welland	Near Husband's Bosworth, Leicestershire	Wye, Chater, Gawsh, Glen	Leicester, N. Northampton, Rutland, S. Lincoln.
Witham	N.N.E. of Oakham	Brant, Longworth, Bain	Rutland, Lincoln.
Humber, Trent Branch	Moorlands of Staffordshire, N. of Burslem	Sow, Tame, Dove, Derwent, Soar, Erewash, Devon, Idle	Stafford, N. Warwick, Derby, Leicester, N. Rutland, Nottingham, W. Lincoln.
Ditto, Ouse Branch	Pennine Chain, W. Yorkshire	Swale, Ure, Nidd, Wharfe, Derwent, Aire, Calder, Don	Yorkshire.
Esk	Egton Moors, Yorkshire		N.E. Yorkshire.
Tees	Swamp, E. of Cross Fell	Lune, Deepdale, Skerne	N. Yorkshire, S. Durham.
Wear	Killhope Head, W. Durham		Durham.
Tyne, North Branch	Scottish Border, S.W. of Carter Fell	Reed, S. Tyne, Derwent	Northumberland, N. Durham.
Blythe	E. of Cooklaw, near the Roman Wall		Northumberland.
Wansbeck	S.W. of Whelpington, Northumberland		Ditto.
Coquet	Cheviot Hills		Ditto.
Tweed	Hart Fell, S. Peebles-shire	Lyne, Gala, Lauder, Ettrick, Yarrow, Teviot, Till, Whiteadder	Peebles, Selkirk, S. Edinburgh, Roxburgh, Berwick, S. Haddington, N. Northumberland.
Tyne of Haddingtonshire	Moorfoot Hills		E. Edinburgh, Haddington.
Forth, river and estuary	N.E. of Ben Lomond	Teith, Allan, Devon, S. Devon, Bannockburn, Carron, Almond, Leith Water, Esk, Leven	Stirling, S. Perth, Clackmannan, Linlithgow, Edinburgh, Kinross, Fife.
Eden	N.W. of Lomond Hills		Fife.
Tay	E. of the Southern Grampians	Lochie, Lyon, Tumel, Braan, Isla, Almond, Earn	Perth, W. Forfar.
S. Esk	Central Grampians	Prosen, Noran Water	Forfar.
N. Esk	Central Grampians, base of Lochnagar	Saughs Water, Cruick W.	Forfar, Kincardine.
Dee	Mount Braeriach, C. Grampians	Guisachan, Geauly, Feugh W.	Aberdeen, Kincardine.
Don	E. skirts of Ben Aven, C. Grampians	Ury	Aberdeen.
Ythan	Ythan Wells, N.E. of Central Grampians	Kelly	Ditto.
Doveran	N.E. of Central Grampians	Bogie, Islay	Aberdeen, N.E. Banff.
Spey	Loch Spey	Dulnain, Aven	Inverness, Elgin, Banff.
Findhorn	Morass in Monadh Leadh Mountains	Dorback	Inverness, Nairn, Elgin.
Nairn	E. of Loch Ness	Cawdor	Inverness, Nairn.
Beauly	W. of Loch Affarie	Cannich, Farrar	N.W. Inverness.
Conon	Loch Faunich	Meig, Orrin	Ross, Cromarty.
Oikel	W. of Ben More Assynt	Shin, Carron	Sutherland, Ross.

BRITISH ISLANDS :— RIVER SYSTEM.

RIVER-SYSTEM OF THE SOUTHERN BASIN, OR ENGLISH CHANNEL.

RIVERS.	SOURCE.	AFFLUENTS.	COUNTIES DRAINED IN WHOLE OR IN PART.
Rother	Near Rotherfield, Sussex		E. Sussex, S.W. Kent.
Southern Ouse	St. Leonard's Forest, Sussex	Glynde	Sussex.
Adur	S.W. of Horsham		Ditto.
Arun	Near Hind Head, Surrey	Rother	E. Hants, S. W. Surrey, Sussex.
Itchin	N.E. of Winchester		Hants.
Anton	Near Andover	Teste	Ditto.
Southern Avon	Near Devizes	Bourne, Nadder, Stour	Wilts, S.W. Hants, E. Dorset.
Frome	N.E. of Beaminster		Dorset.
Axe	N. of Beaminster	Yart	W. Dorset, S.W. Somerset, E. Devon.
Otter	Black Down Hills		E. Devon.
Exe	Exhead, western extremity of Exmoor	Barle, Culm, Creedy	N.W. Somerset, Devon.
Teign	N. of Dartmoor		S. Devon.
Dart	Centre of Dartmoor		Ditto.
Plym	S.W. of Dartmoor		Ditto.
Tavy	W. of Dartmoor	Wallcomb	Ditto.
Tamar	Worley Barrows, S.S.E. of Hartland Point	Carey, Attery, Lyd, Inny	E. Cornwall, W. Devon.
Towey	S.E. of Cameltord		Cornwall.

RIVER-SYSTEM OF THE WESTERN BASIN, OR ATLANTIC OCEAN, INCLUDING THE BRISTOL CHANNEL.

RIVERS.	SOURCE.	AFFLUENTS.	COUNTIES DRAINED IN WHOLE OR IN PART.
Severn	E. side of Plynlimmon, Wales	Vyrnwy, Tern, Stour, Teme, Avon	Montgomery, Salop, S. Stafford, Worcester, Warwick, N.W. Northampton, E. Hereford, Gloucester.
Wye	S.E. side of Plynlimmon	Elan, Ithon, Irvon, Edwy, Lug, Monnow	Montgomery, Radnor, N.E. Brecknock, Hereford, E. Monmouth.
Usk	N. side of Caermarthenshire Beacons	Nant Bran, Tarrel, Honddu, Grwyne, Ebwy	Brecknock, Monmouth.
Towy	S.E. of Tregaron	Cothi, Gwili	S.E. Cardigan, Caermarthen.
Avon	N. of Tetbury	S. Frome, Chew, N. Frome	N. Wilts, N. Somerset, S. Gloucester.
Parret	N.E. of Crewkerne	Isle, Yeo, Tone, Cary	N.W. Dorset, Somerset.
Taw	Taw Head, N. of Dartmoor	Little Dart, Mole	Devon.
Torridge	S.E. of Hartland Point	E. and W. Okement	Ditto.
Alan or Camel	N. of Camelford		Cornwall.
Barrow, Ireland	Glenbarrow, Slievbloom Mountains	Nore, Suir	Queen's County, S. King's County, W. Kildare, W. Carlow, Tipperary, Kilkenny, N. Waterford, S.W. Wexford.
Blackwater	Mountains of Kerry	Allo, Awbeg, Funcheon, Bride	E. Kerry, Cork, S.W. Tipperary, W. Waterford.
Lee	Lake Gnagann Barra	Sultane	Cork.
Bandon	Shehy Mountains		Ditto.
Shannon, river and estuary	Legnashinna, Shannon Pot	Boyle, Black, Inny, Suck, Brosna, Nenagh, Mulkear, Maig, Deel, Feale, Fergus	N.W. Cavan, Leitrim, Longford, Roscommon, Westmeath, King's County, S.E. Galway, N. Tipperary, Clare, Limerick, N. Kerry.
Foyle	S. of Tyrone	Drumragh, Fairy, Derg, Owenkillew, Finn, Deel, Faughan	Tyrone, Donegal, W. Londonderry.
Bann	King's Meadow, Mourne Mountains	Blackwater, Moyola, Main	W. Down, N. Armagh, N. Monaghan, E. Tyrone, E. Londonderry, Antrim.
Stinchar, Scotland	Lakes, S.E. of Ayrshire	Dusk	Ayrshire.
Girvan	Ditto		Ditto.
Doon	Ditto		Ditto.
Ayr	Haughshaw Hills	Lugar	Ditto.
Clyde	Near Queensberry Hill	Duneaton, Avon, Medwin, Calder, Kelvin	Lanark, Renfrew, S. Stirling, Dumbarton.

The water-parting northward in Scotland, between the Atlantic basin and that of the German Ocean, being everywhere at no great distance from the west coast, the Atlantic only receives a few more very unimportant streams.

RIVER SYSTEM OF THE CENTRAL BASIN, OR IRISH SEA, INCLUDING ST. GEORGE'S CHANNEL.

RIVERS.	SOURCE.	AFFLUENTS.	COUNTIES DRAINED IN WHOLE OR IN PART.
Slaney, Ireland	Near Mount Lugnaquilla	Derreen, Derry, Bann, Urn, Boro	S.W. Wicklow, E. Carlow, Wexford.
Ovoca	Crockan Pond	Avonmore, Avonbeg	Wicklow.
Liffey	Liffey Head, near Mount Kippure	Rye	N. Wicklow, E. Kildare, Dublin.
Boyne	Bog of Allen, near Edenderry	Yellow, Deel, Blackwater	N.W. Kildare, N.E. King's County, E. Westmeath, S. Louth.
Teify, Wales	Lake Teify, N.E. of Tregaron		Cardigan, N. Caermarthen, N. Pembroke.
Dovey	S. slope of Arran Fowddy		S. and E. Merioneth, W. Montgomery.
Conway	Lake Conway	Ledau, Llugwy	E. Caernarvon, W. Denbigh.
Dee	W. slope of Arran Fowddy	Treveryn, Alwin, Cerlog, Alyn	Merioneth, Denbigh, E. Flint, W. Cheshire.
Mersey, river and estuary, England	Holme Moss	Tame, Goyt, Ethrow, Irwell, Irk, Bollin, Weaver	S. Lancashire, Cheshire.
Ribble, river and estuary	Ribble Head, E. of Wharnside	Hodder, Calder, Darwen, Douglas,	N.W. Yorkshire, Lancashire.
Lune	S. Slope of Shap Fells	Rother, Leckbeck, Greta, Wenning	S. Westmoreland, N. Lancashire.
Eden	S. of Kirkby Stephen	Eamont, Caldew, Petterill, Irthing	Westmoreland, Cumberland.
Esk, Scotland	S. Slope of Ettrick Pen	Liddel, Line	E. Dumfries, N. Cumberland.
Annan	Near Hart-Fell	Evan, Moffat, Kinnel, Dryfe	Dumfries.
Nith	E. Ayrshire	Skarr, Cluden	E. Ayrshire, W. Dumfries, E. Kirkcudbright.
Dee	Loch Dee	Dengh, Ken	Kirkcudbright.

N.B.—Some confusion is apt to arise from different rivers bearing the same name. There are no less than nine Avons, five Esks, four Ouses, three Rothers, three Dees, and three Derwents.

The Humber, including Trent and Ouse, is the largest river of the British Islands in regard to the area of its basin, which is equal to nearly one-sixth of the total area of England and Wales. The waters of the upper and lower Trent run in exactly opposite directions, from north to south, and from south to north.

The Severn, ranking second in the magnitude of its basin, is the first in point of length, the distance along the river being about twice the direct distance from source to mouth, owing to its curvilinear course.

The Shannon is superior to all other British rivers in the length of its navigation, which extends to Lough Allen, 213 miles from its mouth, that of the Severn extending to Welshpool 192, and of the Thames to Lechlade, 193 miles from their mouths. The fall of the Shannon exhibits a rare exception to the general fall of rivers, being the greatest in the lower part of its course. From Lough Allen to Lough Dearg, a distance of 131 miles, it descends only at the rate of 4¾ inches per mile, but from Castle Connel to Castle Troy, between Lough Dearg and Limerick, the descent amounts to nearly 17 feet per mile, the river forming in this part of its course the magnificent rapids of Doonas, where the navigation is conducted by artificial cuts.

The Thames, commercially the most important river of the globe, is only the fourth in point of magnitude belonging to the United Kingdom, but ranks first as a tidal river. The tidewater extends about 64 miles, from the Nore Light to Teddington (Tydington). The time of high water at Teddington Lock is about two hours later than at London Bridge. Between Westminster and London

Bridge, the mean velocities of flood and ebb, are 3 miles per hour, extreme $3\frac{1}{2}$; ebb $3\frac{1}{8}$, extreme $3\frac{3}{4}$.

The Avon and Nen—the Calder branch of the Ribble, and the stream of the same name which belongs to the system of the Humber—the Eden, and the Swale and Ure which form the Yorkshire Ouse—the Tweed and Clyde—are examples of rivers having closely contiguous sources, and flowing off to opposite seas. The Tweed and Clyde occasionally exhibit an instance of bifurcation, explained as follows:—"It is a singular circumstance, that salmon and their fry have occasionally been taken in the upper parts of the Clyde, above its loftiest fall, which being 80 feet in height, it is utterly impossible for fish of any kind to surmount. The fact is accounted for in this way. After passing Tinto Hill, the bed of the Clyde approaches to a level with that of the Biggar Water, which is close at hand, and discharges itself into the Tweed. On the occasion of a large flood, the two streams become connected, and the Clyde actually pours a portion of its waters into one of the tributaries of the Tweed, which is accessible to and frequented by salmon."

The Tay, the monarch of Scottish streams, is remarkable for the immense volume of water it discharges into the sea, amounting in a mean state, to 218,159 cubit feet per minute, as ascertained by a careful measurement of Dr. Anderson. Its tributaries exhibit an epitome of everything connected with the action of running water, the erosion of rocks, the origin of river-valleys, and the changes they undergo. In Breadalbane, the Dochart may be observed filling up the lake of that name, and at Killen sawing down the rocks which form the cataract; a process, which, if more rapid, might anticipate the former, and drain the lake before its conversion into an alluvial plain. The deep ravines of the Keltnie prove the immense power of even inconsiderable streams acting through long periods, also shown by the Tumel in its lower cataracts, whose retrogression is a picture of that of Niagara, as the wide valley above Birnam Pass shows what Lake Erie is destined to become when that mighty torrent has cut its way backward to it.—*Nicol's Geol. of Scotland.*

The Dee of Aberdeenshire has the greatest descent of the British rivers, taking its rise from a well or spring at the height of 4060 feet on Mount Braeriach, one of the Cairngorm group. The fall of some of the principal rivers is as follows:

	Feet.
Dee	4060
Ovoca	1770
Liffey	1631
Tweed	1500
Barrow	1500?
Clyde	1400
Trent	700?
Severn, from Newtown	465
Thames	376
Shannon	345

The Spey, in the lower parts of its course, is remarkable for its rapid current, whilst in the upper it slumbers in dark mossy lakes.

The British rivers present a few examples of a subterranean flow. The Alyn, an affluent of the Welsh Dee, after breaking through the Flintshire hills, passes through a subterraneous passage for the distance of rather less than a mile, and then enters the plain of Cheshire. In Glamorganshire, the Melte runs for nearly a quarter of a mile through the dark hollow of the Cwm Porth, while cattle graze, and harvests wave upon the incumbent rock. Near Wells, in Somersetshire, in the limestone of the Mendip Hills, a three-chambered cavern occurs, with a fine stream running through the farther end, which sinks through a cleft of the rock, and bursts out in the adjoining valley as the source of the north Axe. The Aire, an affluent of the Yorkshire Ouse, has its source probably in Malham Tarn in Craven, but runs underground for about a mile, and issues at the base of the lofty amphitheatre of limestone rocks, called Malham Cove. The Hamps and Manifold, two small streams on the borders of Derbyshire and Staffordshire, belonging to the system of the Trent, sink into the disjointed limestone strata of the district, and after running underground for several miles emerge in the vicinity of Ilam Hall. In the west of Ireland, several lakes with affluents but without apparent outlets, probably cast off their surplus waters by subterranean channels. Lough Mask has a subterraneous communication with Lough Corrib through the narrow isthmus between them. In that locality several considerable streams dip underground, sink and emerge frequently, and finally disappear without any visible outlet.

HYDROGRAPHICAL TABLE OF THE MORE IMPORTANT RIVERS OF THE UNITED KINGDOM, ARRANGED ACCORDING TO THE AREAS OF THEIR RESPECTIVE BASINS.

RIVERS.	AREA OF BASIN IN SQ. MILES.	LENGTH IN MILES.	REMARKS.
Humber — Ouse Branch	4290	160 to Swale Head	Tide ascends the Ouse to the lock at Naburn, about 4 miles below York, and its affluent, the Wharfe, to Tadcaster-bridge.
Humber — Trent Branch	4082	171	The entire fall of the Trent from the moorlands of N. Stafford is probably 700 feet. Tidal water extends 7 or 8 miles above Gainsborough.
Humber — Estuary	1178	39	Ouse and Trent join at Faxfleet, and form the Humber.
Humber	9550		
Severn, including all the rivers of the estuary — Severn Proper		239	The length includes that of the estuary to the sea at Flatholmes. Limit of tide-water, Gloucester.
Severn, including all the rivers of the estuary — Wye		120	Remarkable for picturesque beauty in the red sandstone region of S. Wales, and the height of its tides at Chepstow.
Severn, including all the rivers of the estuary — Usk	8580	60	Navigable to Newport.
Severn, including all the rivers of the estuary — Avon		100	The Avon flowing to the Bristol Channel has its source in Naseby Field, Northamptonshire, where a branch of the Nen rises, running in an opposite direction to the Wash.
Shannon	6946	224	Length to the sea between Loop and Kerry Head.
Thames — Thames Proper	6160	215	Length to the Nore Light. Limit of tide-water at Teddington, upwards of 17 miles above London-bridge.
Thames — Medway		45	Length from the branch S. of Tunbridge Wells to Rochester-bridge.
Barrow	3410	114	Barrow, Suir, and Nore, rising in the same range of mountains, and forming a junction after a long separate course, are called the Three Sisters.
Great Ouse	2960	150	Remarkable for its tortuous course, the direct distance from source to mouth being not more than 80 miles.
Bann	2345	100	Lough Neagh divides the river into the Upper and Lower Bann. The direct distance from source to mouth is about 75 miles.
Tay	2250	130	Length to Button Ness, N. boundary of the estuary.
Tweed	1870	96	The Tweed has an entire fall of about 1500 feet. Tide ascends the river 10 or 12 miles.
Mersey	1743	70	Length to Rock Perch, S. entrance of the estuary. Tide ascends to Warrington.
Clyde	1580	98	The Clyde is only navigable up to Glasgow, which is also the limit of tide-water.
Avon (Wiltshire)	1210	70	The largest river of the S.W. chalk district, navigable up to Salisbury.
Spey	1190	96	The wildest and most capricious of the larger British rivers.
Yare	1180	60	The navigation, aided by artificial cuts, extends to Norwich.
Blackwater	1165	100	Navigable to Fermoy.
Nen	1132	100	A slow winding river, navigable to Northampton.
Tyne	1100	80	Length of the S. Tyne branch. Tide ascends 6 or 7 miles above Newcastle.
Foyle	1100	80	Navigable to St. Johnstown, and aided by cuts to Strabane.
Witham	1050	70	Navigable to Lincoln, and connected by the Fossdyke with the Trent at Torksey.
Boyne	1002	70	Navigable for small barges as far as Navan.
Eden	995	72	Tide occasionally runs up to within 4 miles of Carlisle.
Dee (Wales)	862	80	The estuary forms a noble arm of the sea at high-water, but at its ebb dwindles down into an insignificant stream.
Tees	744	80	Remarkable for the beautiful valleys and waterfalls of its upper course.
Slaney	734	70	Navigable to a few miles above Enniscorthy.
Ribble	720	60	Estuary fordable at low water at Hesketh Bank, where it is 4 miles wide.
Welland	708	60	Navigable to Stamford.
Dee (Aberdeenshire)	705	87	The Dee has the highest source of any river in the United Kingdom.
Parret	653	45	Near the junction of the Tone with the Parret, a rising ground marks what was once the Isle of Athelney.
Forth	645	60	Length to the head of the Firth. The Firth extends about 50 miles, and is about 15 miles wide at its mouth, between Fifeness and Tantallan Castle rocks.
Exe	643	55	Tide ascends the river to Countess Wear, about 2 miles below Exeter.
Tamar	603	55	Tide ascends to the Weir-head, 17 miles from Devil's Point.
Lee	595	60	The estuary forms the fine harbour of Cork.
Don	530	50	Height of its source, 1640 feet.
Towy	506	70	Tide runs up above Caermarthen.

N.B.—The areas are given from Mr. Petermann's Hydrographical Map of the British Isles, founded on original calculations. The lengths are approximate estimates.

BRITISH ISLANDS:—LAKES AND TARNS.

LAKES.—The examples of any importance in England are in the north-west mountain region, where, though numerous, they are more remarkable for picturesque beauty than for magnitude. Wales contains a great number of highland pools and tarns, with two more considerable expanses, Llyn Tegid or Bala Pool in the north, and Llyn Safadhu, or Brecknock-mere, in the south. Scotland and Ireland are eminently lacustrine. The Scotch lakes are mostly long, narrow, and confined, occupying hollows between the mountains, the length far exceeding the breadth. The Irish lakes are upon a larger scale, and have their length and breadth more proportionate.

TABLE OF SOME PRINCIPAL LAKES AND TARNS IN THE BRITISH ISLES.

LAKES AND TARNS.	SITUATION.	REMARKS.
ENGLAND.		
Winander-mere	Border of Westmoreland and N. Lancashire.	Largest lake of South Britain, bounded by gentle slopes, discharging its waters by the Severn into Morecambe Bay. Height above the sea, 108 feet; greatest depth, 200 feet; noted for its char; nearly 11 miles long by from 1 to 2 wide. It contains 13 islands, and covers about 4534 acres.
Grassmere	Westmoreland.	Affluents of Winander-mere; Grassmere 180, and Esthwaite-water 198 feet above the sea.
Rydal-water	,,	
Elter-water	,,	
Esthwaite water	N. Lancashire.	
Coniston-water	,,	Parallel to Winander-mere, 6 miles long by from ½ to ¾ broad, fed from Coniston Fells, at the N. extremity, and discharging into Morecambe Bay. Height above the sea, 105 feet; greatest depth, 240 feet.
Ulleswater	Border of Westmoreland and Cumberland.	9 miles long by 2 at the broadest; height above the sea, 318 feet; greatest depth, 210 feet; bounded by steep crags, green valleys, and lofty barren mountains; discharges by a branch of the Eden.
Red Tarn	Ditto on Helvellyn.	Affluents of Ulleswater (2400 feet above the sea.
Grisdale Tarn	Westmoreland.	Affluents of Ulleswater (1705 ,, ,,
Hawes-water	,,	714 feet above the sea; a small lake of remarkable beauty; discharges by a branch of the Eden.
Kentmere Tarn	,,	Near the head waters of the Kent, the river of Kendal.
Wast-water	Cumberland.	3 miles long by ¾ broad; at the foot of Scaw Fell; 160 feet above the sea; 270 feet, greatest depth; discharges by the Irt.
Emmerdale-water	,,	2½ miles long by ¾ broad; 80 feet, greatest depth; discharges by the Eden.
Devock-water	,,	On the Esk River.
Burnmoor Tarn	,,	One of the sources of the Esk, near Scaw Fell.

	Length. Miles.	Breadth. Miles.	Depth. Feet.	Height above the Sea. Feet.	
Derwent-water	3	1½	72	223	The Floating Island, formed of vegetation closely matted together, and the Bottom-wind, a disturbance of the surface caused by the escape of sub-aqueous currents of air, occasionally observed in Derwent-water, are the most remarkable phenomena of the English lake district.
Bassenthwaite-water	4	1	68	210	
Lowes-water	1	⅛	64	—	
Crummock-water	3	¾	132	273	
Buttermere	1½	½	90	—	
Thirlmere	2½	1	108	—	
Sparkling Tarn	—	—	—	1900	

Marton-mere	Lancashire.	Between the Ribble and the Wyre, now considerably reduced.
Malham Tarn	Yorkshire, W. R.	A fine sheet of water, a few miles east of Settle.
Heigham Ponds	Norfolk.	Meres, near the N.E. coast, plentifully stocked with fish, and frequented by wild-fowl.
Braydon-water	,,	Near Yarmouth, at the outfall of the Yare.
Lake Lothing	Suffolk.	Near Lowestoft, on the Waveney, connected with the sea by an artificial cut.
Whittlesea-mere	Huntingdon.	2¼ miles long by 1¼ broad, occupying 1750 acres; a great resort of wild-fowl.
WALES.		
L'yn Tegid (Bala Pool)	Merioneth.	4 miles long by 1 broad; average depth, 40 feet; remarkable for the purity of its water.
,, Conway	,,	Source of the Conway River; 1 mile long by ¾ broad; surrounded by deep bogs and masses of rock.
,, Llanberris	Caernarvon.	Two beautiful lakes on the Seiont, flowing into the Menai; upper lake upwards of 400 feet deep.
,, Cwellyn	,,	1½ miles long by ¾ broad; 508 feet above the sea; on the Gwyrval flowing into the Menai.
,, Gwynant	,,	Mountain lakes on the Glaslynn, descending from Snowdonia into Cardigan Bay.
,, y Dinas	,,	
,, Ogwen	,,	Source of the Ogwen River, near the centre of Snowdonia; 900 feet above the sea; wild and picturesque in the extreme.
,, Teify	Cardigan.	The largest of seven very deep lakes, near the Abbey of Strata Florida.
,, Safadhu	Brecknock.	3 miles long by 1 broad, the largest lake of South Wales.

SCOTLAND.		Length. Miles.	Greatest Breadth. Miles.	Area. Sq Miles	
Loch Lomond	Border of Dumbarton and Stirling.	24	7	45	The "lake full of islands," about 30 in number, 10 of which are of considerable extent, finely clothed with wood; largest lake of Great Britain; abounding in fish.
,, Awe	Argyle.	25	2½	30	Surrounded by lofty mountains; contains 24 small islands, some of them beautifully crowned with trees; 130 feet above the sea.
,, Ness	Inverness.	22	2½	30	In the tract of the Caledonian Canal; 53 feet above the sea; greatest depth upwards of 800 feet; never freezes.
,, Shin	Sutherland.	20	1½	25	In the great hollow which crosses Scotland from Loch Laxford to the Dornoch Firth, rivalling Glenmore.
,, Marce	Ross.	12	3	24	Full of small islands, covered with scattered firs, and thickets of holly. Its neighbourhood is the only abode of the gray eagle in Great Britain.
,, Tay	Perth.	15	2	20	Fine view of the gigantic Ben Lawers from the southern shore.
,, Arkeig	Inverness.	12	2	18	Surrounded with dark and lofty mountains; banks frequented by herds of Lochiel's celebrated red-deer.
,, Shiel	,,	16	1	16	In a mountainous district on the west coast.
,, Lochy	,,	16	1	15	In the tract of the Caledonian Canal; 83 feet above the sea; 480 feet deep; environed with wild, stupendous, and scantily-wooded hills.
,, Laggan	,,	8	1½	12	On the Spean, in the wild highland country of Lochaber.
,, Morier	,,	9	2	12	On the west coast, in the heart of a rural highland country.
,, Pannich	Ross.	7	1½	10	Inclosed on all sides by very steep and high mountains, bare of vegetation.
,, Ericht	Perth and Inverness.	14	2	10	Never freezes, owing to its great depth. An old tradition affirms that it was once an inhabited valley, submerged in a single night with all its population.
,, Earn	Perth.	8	1½	9	Bounded on the S. by Ben Voirloch (Great Mountain of the Lake), presenting a continued succession of bold precipices, deep hollows, torrents, and woods; 350 feet above the sea.
,, Naver	Sutherland.	6	2	9	N. of Ben Klibreck, surrounded by monotonous brown moors and bogs.
,, Stennis	Mainland, Orkney.	8	2	8	In a low barren country, haunted by sea-fowl.
,, Rannoch	Perth.	9	1	8	E. of the moor of Rannoch, an elevated plain, now totally barren, but once a forest, roots and trunks of trees being seen in every ditch and stream.
,, Leven	Kinross.	4	2	7	363 feet above the sea; contains four islands, on one of which are the picturesque ruins of Lochleven Castle, the only lake of any extent which does not belong to the Highlands.
,, Fuir	Ross.	4	2	6	In a desolate country, N. of Loch Maree.
,, Lydoch	Perth and Argyle.	6	1	6	On the moor of Rannoch.
,, Ken	Kirkcudbright.	10	¾	6	Largest lake of S. Scotland; 148 feet above the sea; abounds in fish.
,, Layzhal	Sutherland.	6	1	6	In the mountainous country near the N. coast.
,, Glass	Ross.	5	1	5	At the N. base of Ben Wywis.
,, Katerine	Perth.	8	¾	5	Remarkable for its fine scenery; 352 feet above the sea.
,, Doon	Ayrshire.	9	1	4½	Encircled with a rocky margin; abounds in trout.
,, Luichart	Ross.	3	1	3	Precipitous shores, covered with wood.
,, Lubnaig	Perth.	4½	½	2¼	Bounded on the W. by the mountain-wall of Ben Ledi.

BRITISH ISLANDS:—CLIMATE AND TEMPERATURE.

TABLE OF SOME PRINCIPAL LAKES AND TARNS IN THE BRITISH ISLES—*Continued.*

LAKES AND TARNS.	SITUATION.	Length. Miles.	Greatest Breadth. Miles.	Area. Acres.	Height above the Sea. Feet.	REMARKS.
Loch Aven	Banff.					This crystal sheet of water, nearly 2 miles long, and 1750 feet above the sea, is the most elevated of the same size in the United Kingdom, remarkable for its loneliness, difficult access, and frightful precipices, which approach to the wilder and more savage parts of Swiss scenery. It lies embedded in the Central Grampians, surrounded by the highest mountains of Great Britain. The enormous masses of Ben MacDui and of Ben Main overhang its southern extremity, while the Cairngorm and Ben Buinae rise almost perpendicularly from its northern and western sides. The surface of the lake, notwithstanding it elevation, has no sunshine for several of the winter months. No tree or shrub grows on its banks, and few living creatures are ever seen besides the eagle and the ptarmigan, or some straggling red deer from the Forest of Mar.
IRELAND.						
Lough Neagh	Londonderry, Antrim, Down, Armagh, Tyrone.	20	12	101,379	48	Largest lake of the British Isles; greatest depth, 102 feet; celebrated for the petrifying quality of its waters; tame low shores. Ram Island contains one of the ancient round towers. The area includes that of Lough Beg, connected with it on the north.
,, Corrib	Galway, Mayo.	24	14	43,484	30	Contracted in the middle to a narrow channel crossed by a ferry.
,, Erne	Fermanagh.	30	5	36,923	150	The length and area include the two lakes. The Upper Erne, much the smallest, embraces 90 islands, one of which, Inishmore, contains 2900 acres. The lower Erne, the most beautiful, called the Winander-mere of Ireland, comprises 109 islands; water harsh and unwholesome; greatest depth, 225 feet, but very variable.
,, Derg	Galway, Tipperary, Clare.	23	4	29,576	110	An expansion of the Shannon, bounded on the S. by high mountains.
,, Ree	Roscommon, Longford, Westmeath.	17	6	—	125	On the Shannon; contains several islands; low shores, liable to extensive winter floods.
,, Mask	Galway, Mayo.	9	4	22,219	68	About three miles N. of Lough Corrib, with which it communicates by a subterraneous channel in the limestone isthmus. The stream in its caverned bed is visible at several places, through openings on the passage, the most remarkable of which is the Pigeon's Hole, 60 feet deep, which may be descended.
,, Conn	Mayo.	12	4	14,030	40	Including the closely contiguous and connected Lough Cullin.
,, Allen	Leitrim, Roscommon.	8	3	—	161	Near the head waters of the Shannon; gloomy and exposed to violent squalls.
,, Melvin	Fermanagh, Leitrim.	7½	1½	5,541	90	Diversified with wooded islands; bold southern shores.
,, Killarney, Lower Lake	Kerry.	4½	2	3,000	68	Contains 33 beautiful islands; greatest depth, 252 feet.
,, Derg	Donegal.	2½	2½	2,140	467	Bounded by dreary moorland hills; subject to violent gusts of wind; greatest depth, 75 feet; famous for St. Patrick's Purgatory on Station Island.

WATERFALLS. There are several fine falls in the lake district of England, Wales, the Highlands of Scotland, and the mountain regions of Ireland, in a few instances forming magnificent cataracts by their height or volume of water:

	Height. Feet.
Scale Force, near Buttermere, Cumberland	190
Barrow Cascade, two miles from Keswick, ditto	124
Lowdore Cascade, near Keswick, ditto	100
Sour Milk Force, near Buttermere, ditto	90
Airey Force, Gowbarrow Park, ditto	80
Nunnery Cascade, Croglin, ditto	60
Mickle Force, a fall of the Tees, near Middleton, in Teesdale, Durham	69
Langdon Beck, at the confluence of that stream with the Tees, below Mickle Force	30
Aysgarth Force, on the Ure, near Askrigg, York, N. R.	
Cascade of Whethercot, in a cavern, near Ingleton, York, W. R.	70
Thornton Force, a beautiful fall, near Ingleton, ditto	90
Lyd Fall, an affluent of the Tamar, Devonshire	100
Falls of the Conway, remarkable for grand scenery, Caernarvonshire.	
Glasslyn Cascade, near its source in Snowdonia, ditto	300
Fall of the Ogwen, three descents, ditto	300
Falls of the Cynfael, upper and lower, near Festiniog, Merioneth	140
Pistil-y-Mawddach, three descents of the Mawddach, ditto	90
Rhaiadr Du, principal fall of the Camlan, an affluent of the Mawddach, ditto	50
Pistil-y-Cayne, grand fall of the Cayne after heavy rains, amid rocks mantled with woods, ditto	200
Pistil Rhaiadr, grand fall of the Rhaiadr, an affluent of the Tanat, Montgomery	200
Falls of the Mynach, four descents, at the Devil's Bridge, Cardiganshire	208
Ysgwd Einon Gam, lame Einon's waterfall, on the Purthen, Glamorgan	80
Clungwyn, upper part of the Melte, ditto	70
Fall of the Hepste, richly adorned with trees and underwood, ditto	40
Bonnington Linn, on the Clyde, Lanark, 30 feet. } Total descent of the Clyde,	
Corra Linn, ,, ,, 84 } from the first to the last	
Dundaff Linn ,, ,, 4 } fall, a distance of three	
Stonebyres Fall ,, ,, 80 } miles	230
Grey Mare's Tail, on the outlet of the "dark Loch Skene," Dumfries	300
Acharn Cascade, S. side of Loch Tay, Perth	80
Falls of Brack Linn, formed by the Keltie, near Callendar, ditto	50
Falls of Bruar, near Blair Athol, highest, ditto	60
Falls of Moness, near Aberfeldy, upper and highest, ditto	50
Fall of the Isla, an affluent of the Tay, in Glen Isla, Forfar	80
Linn of Dee, four small descents of the Dee above Braemar, Aberdeen	30
Fall of the Spey, above the Church of Aberfour, Banff	30
Falls of Foyers, in Strath Errick, on the east of Loch Ness, Inverness, regarded as the most imposing in the United Kingdom, upper fall 70 feet, lower 207	277
Powerscourt, Wicklow, a descent of the Dargle, a mountain stream often limited in its supply of water	300
Cataract of Hungry Hill, Cork, formed by the Adrigole stream, subject to the same casualty	700

The confluence of streams, an interesting and often an imposing physical incident, is nowhere in the British Isles displayed under circumstances of greater attraction, than in the basin of the Ovoca, Wicklow. The spot where that river is formed by the junction of the Avonmore and Avonbeg, called the first "Meeting of the Waters," a few miles south of Rathdrum, is a scene of great beauty, inclosed by high grounds covered with fine natural woods, which command magnificent views of the Wicklow Mountains. From the confluence, the Ovoca winds through the loveliest valley in Ireland, between high banks adorned with an unbroken range of forest, to its union with the Aughrim, a stream descending through a glen from the base of Lugnaquilla, constituting the second "Meeting of the Waters."

CHAPTER VI.

CLIMATE.

TEMPERATURE.—The physical circumstances which determine the moderate and uniform temperature of Western Europe, compared with the continental climates of the northern hemisphere in corresponding latitudes, have been stated in a previous part of this work, (p. 58.) The British archipelago, exposed by geographical position to the full influence of those circumstances, experience a temperature at least 20° warmer, and ranging to far inferior degrees of heat and cold than would be the case if the great valley of the North Atlantic were to be filled up, and Europe to be connected with America, the prevailing south-west winds sweeping across a continent instead of travelling over the warm waters of the Gulf Stream.

Observations need to be greatly extended before a complete article on British Climatology can be furnished; but the facts already registered suffice for a few general conclusions. The following Table, derived from the labours of Professor Dove, states the mean annual temperature at different latitudinal points of the kingdom, with the summer and winter means. The usual meteorological seasons are meant, summer, including June, July, August; winter, December, January, February.

Places.	Lat.	Mean Temperature of The Year.	Winter.	Summer.	Difference.
Unst	60° 45′	44·70	38·68	52·68	14·00
Stromness	58 57	46·34	39·35	54·42	15·07
Wick	58 29	46·94	38·82	55·33	16·51
Aberdeen	57 9	49·18	39·03	59·53	20·52
Edinburgh	55 58	47·13*	38·45	57·17	18·72
Leadhills	55 25	44·12†	33·37	55·73	22·36
Carlisle	54 54	46·97	37·25	57·39	20·14
Belfast	54 37	52 09	41·35	63·85	22·50
Keswick	54 33	47·28‡	37·53	58·60	21·07
Kendal	54 17	47·05	37·04	57·79	20·75

* 220 feet high. † 1280 feet. ‡ 240 feet.

BRITISH ISLANDS:—CLIMATE AND TEMPERATURE.

Places.	Lat.	Mean Temperature of The Year.	Winter.	Summer.	Difference.
Lancaster	54° 3′	46·36	37·08	56·83	19·75
York	53 57	49·16	36·28	62·37	26·09
Dublin	53 21	49·05	39·83	59·57	19·74
Manchester	53 29	48·81	38·33	59·80	21·47
Liverpool	53 25	50·80	41·30	61·14	19·84
Derby	52 58	44·92	36·33	54·33	18·00
Boston	52 48	49·12	37·74	61·98	24·24
Malvern	52 7	47·74	40·00	60·00	20·00
Bedford	52 8	51·64	40·51	62·68	22·17
Cheltenham	51 54	51·54	40·60	64·32	23·72
Oxford	51 46	48·64	37·00	60·37	23·37
London	51 30	50·83	39·50	62·93	23·43
Bristol	51 27	51·67	40·33	64·33	24·00
Chichester	50 52	49·51	38·85	60·78	21·93
Gosport	50 47	51·82	40·97	62·74	21·77
Exeter	50 43	46·75	36·33	57·67	21·34
Truro	50 16	50·87	41·63	58·37	16·74
Falmouth	50 9	50·27	42·31	58·45	16·14
Penzance	50 7	51·78	44·23	60·91	16·68

There is thus a difference of 7·08 in the mean temperature of the year at Unst in the Shetlands, at the extreme north of Great Britain, and at Penzance in the extreme south, mainly due to difference of latitude. In a few instances, a considerable discrepancy appears in the temperature of places in very nearly the same latitude, and at a corresponding elevation above the sea level. Exeter and Gosport furnish an example, the former place being 5·07 colder than the latter. This is no doubt caused by the warm south-west winds reaching Gosport without passing over elevated land, and having their temperature diminished by the high granitic plateau of Dartmoor, on their passage to Exeter.

The more temperate character of the climate of the kingdom may be strikingly exhibited by a comparison of mean annual temperatures given in round numbers, between British and Continental places, at latitudes closely corresponding, and at elevations above the sea marked with no important difference:

British.	Temp.	Continental.	Temp.
Unst	44°	St. Petersburg	38°
Aberdeen	49	Nain (Labrador)	25
Edinburgh	47	Kasan	35
		Moscow	38
Carlisle	46	Tilsit	44
Boston	49	Tambov	41
Cheltenham	51	Orenburg	35
Bedford	51	Irkutsk	30
Penzance	51	Cracow	46

In the east of North America, the zone of perpetually frozen subsoil descends to a distance from the equator parallel to that of the vale of York in Britain, and in Central Asia corresponding to that of the north bank of the Thames.

The least difference between the summer and winter means in Great Britain, or the nearest approach to equality in the distribution of temperature, occurs at the opposite extremities, Unst, Stromness, and Wick in the north, Truro, Falmouth, and Penzance. These are specially maritime sites, with minima extremes of heat and cold, in summer and winter, by day and by night, one of the features discriminating maritime from continental climates. But the vicissitudes of temperature experienced at different places will best appear from comparison of the means of the coldest and hottest months.

Places.	Mean Temperature of The Coldest Months.		The Hottest Months.		Difference.
Unst	37·00	December.	54·5	August.	17·50
Stromness	38·05	January.	55·37	July.	17·32
Wick	37·93	February.	56·47	,,	18·54
Aberdeen	37·82	January.	60·47	,,	22·65
Edinburgh	37·38	,,	58·69	,,	21·31
Leadhills	32·00	,,	57·2	,,	25·20
Carlisle	36·19	,,	58·48	,,	22·29
Belfast	40·02	,,	64·24	,,	24·22
Keswick	36·20	December.	59·68	August.	23·48
Kendal	33·97	January.	58·99	July.	25·02
Lancaster	36·55	,,	57·71	,,	21·16
York	33·39	,,	63·51	August.	30·12
Dublin	38·49	,,	60·71	July.	22·22
Manchester	36·7	,,	60·8	,,	24·10
Liverpool	39·95	,,	62·00	August.	22·05
Derby	33·5	December.	55·5	July.	22·00
Boston	35·97	January.	63·01	,,	27·04
Malvern	38·00	,,	61·8	,,	23·80
Bedford	38·08	,,	64·31	,,	26·23
Cheltenham	38·25	,,	66·33	,,	28·08
Oxford	36·9	January.	61·6	July.	24·70
London	36·2	,,	63·60	,,	27·4
Bristol	36·00	,,	67·00	,,	31·00
Chichester	36·46	,,	62·22	,,	25·76
Gosport	38·99	,,	64·03	,,	25·04
Exeter	34·00	,,	59·00	,,	25·00
Truro	40·00	February.	59·9	August.	19·90
Falmouth	40·50	,,	58·87	July.	18·37
Penzance	42·62	January.	62·10	,,	19·48

The same places, Unst, Stromness, and Wick, in the north, Truro, Falmouth, and Penzance in the south, exhibit the least difference of temperature between their coldest and hottest months. The difference for Great Britain at a mean is about 24°, which becomes more excessive in proportion as we recede from it eastward into the interior of Europe and Asia, observing a corresponding latitude, the coldest and hottest months varying in their temperature 34° at Hamburg, 41° at Brunswick, 38° at Berlin, 39° at New Strelitz, 37° at Stralsund, 41° at Christiana, and 57° at St. Petersburg. It may be reasonably concluded that the operations so largely carried on by human industry, such as the removal of the natural forests, draining, inclosing, and planting, have not been without their effect upon the climate; but the general temperature has probably not been altered to any appreciable extent within the historic period, only its distribution become more equable, summer heat and winter cold not so strongly contrasting now as formerly.

The most striking feature in the distribution of temperature in the British Isles is the general direction of the isothermals (see Map) of the coldest month north and south, instead of east and west, indicating little or no difference in the winter temperature northward and southward, but a greater degree of cold from west to east. Though Unst is 10° of latitude farther north than Chichester, their winter temperature is about the same. On the other hand, passing from Penzance eastward to Chichester and London, we encounter a temperature about 6° lower in the coldest month in the latter places than at the former. Comparing the extreme limits of the United Kingdom together, it is probable that the eastern coasts of England experience a winter temperature nearly 10° colder than the western coasts of Ireland, a distance of about 500 miles subsisting between them; while there is no sensible difference in the same respect between the northernmost of the Shetlands and the Isle of Wight, the intervening distance amounting to 700 miles. The coldest portion of the kingdom, which is included within the isotherm of 36°, extends along the east coast of Great Britain from the Naze in Essex to the Firth of Forth, and comprehends the counties of Suffolk, Norfolk, Lincoln, Nottingham, Derby, York, great part of Westmoreland, Durham, Northumberland, Roxburgh, Selkirk, Peebles, and Berwick. The obvious cause of the higher temperature of the coldest month on proceeding from the east of Great Britain to the west of Ireland is the greater influence of the westerly winds, and proximity to the Gulf Stream. In a similar manner, on passing to the continent, the coldest month exhibits a gradually lower temperature as we proceed easterly,—Berlin, in a corresponding latitude to Boston, being 9° colder.

The isothermals of the hottest month have their average direction from south-west to north-east. The highest summer temperature, indicated by the isotherm of 64°, distinguishes a portion of the south of England, including the counties of Dorset and Somerset, with parts of Hants, Devon, Wilts, and Gloucester, extending over the Bristol Channel to Swansea. The next warmest region, included within the curve of 62°, comprises the Cornish peninsula, the southern part of South Wales, the whole basin of the Thames, and the country from thence northward to Birmingham and Lincoln. In the north-west of Scotland, comprising the western districts of Inverness, Ross, and Sutherland, the mean temperature of the hottest month is the lowest, or 54°, exhibiting a difference of 10° below the zone where the greatest summer heat prevails.

The temperature of the mountain atmosphere of the British Isles, and the ratio of its decrease with an increase of elevation, are points upon which no particular conclusions can be stated with perfect confidence. The mean annual temperature of Leadhills, at the height of 1280 feet above the sea, is about 44°; and the decrease appears to be in the ratio of 1° of temperature for 366 feet of ascent. Assuming this to be correct, it follows that the inferior limit of constant congelation occurs there at the elevation of about 5000 feet. Farther north,

where the highest summits of Great Britain rise to near 4400 feet, the line of perpetual snow, having a lower altitude consequent upon an increase of latitude, is somewhat closely approached by the culminating points of the island. Hence the higher crests of the Grampians are clothed with snow through the greater portion of the year, and some of the loftiest peaks retain it in beds and patches all the year round, showing the prevalence of a temperature in those elevated regions very little above the freezing point. Dr. Skene Keith, in the middle of July, found the main source of the Dee, near the top of Mount Braeriach, running under an arch of snow. Ben Wyvis has never been known free from snow within the memory of man, except in the remarkably warm season of September, 1826. Sir Hector Munro, of Foulis, the principal proprietor of that mountain, holds his estate in Ross-shire by a singular tenure from one of the early Scottish kings, that of bringing three wainloads of snow from the summit whenever the king shall desire.

Rain.—The effect of the immense oceanic surface on the west and south-west of the British Islands, with the prevailing winds from those quarters, producing a very humid atmosphere, and a more copious amount of rain on the western than on the eastern side, may be readily anticipated. The following Table brings together a number of mean results obtained by the rain-gauge respecting the annual quantity of rain in various parts of the kingdom:

GREAT BRITAIN.

Western Districts.	Inches.	Eastern Districts.	Inches.
Penzance	41	Hastings	28
Helstone	38	Dover	30
Falmouth	40	London	21
Plymouth	40	Epping	26
Exeter	36	Oxford	22
Minehead	31	Aylesbury	21
Taunton	30	Bedford	27
Bath	30	Cambridge	20
Bristol	30	Thwaite	23
Salisbury	35	Thetford	19
Cheltenham	32	Norwich	25
Monmouth	30	Derby	27
Swansea	35	Horncastle	25
Liverpool	35	East Retford	26
Manchester	36	York	23
Bolton	47	Ackworth	26
Kendal	56	Thirsk	24
Coniston	85	Ferriby	27
Whitehaven	52	Shields	25
Keswick	70	Peebles	29
Isle of Man	37	Edinburgh	25
Applegarth Manse	34	St. Andrews	30
Dumfries	36	Clunie	25
Glasgow	30	Alford	28
Greenock	40	Gordon Castle	29
Dunoon	50	Inverness	26
Mean for Western Districts	56½	Mean for Eastern Districts	24½

In Ireland but few results respecting the annual rain-fall have been obtained, but it appears to range from 31 inches at Dublin to 40 at Cork. The great preponderance of rain westward is due to that side of the kingdom receiving the first impression of the westerly winds moistened by the Atlantic, and to the western position of the British mountains. (*For notices of the climate in relation to winds and rain, see pp.* 46, 50.)

CHAPTER VII.

BOTANY.

Numerical estimates of the species comprised in the indigenous flora of the kingdom vary to some extent, owing to some writers incorporating in the list of its proper spontaneous vegetation certain plants which others reject as introduced examples, and owing to differences of opinion respecting the division into species and varieties. But it will involve no material error to state the number of phænogamous or flowering plants at about 1500 species, which comprises many with a doubtful claim to be regarded as natives. Of this number, there are about 1150 species of Dicotyledones, and 350 of Monocotyledones.

Some islands possess a flora peculiar to themselves, and form distinct centres of vegetation, while others contain only the plants which are common to the nearest continent. The last case applies to the British archipelago, which, with one exception, is stocked with the plants of continental Europe. The exception is *Eriocaulon septangulare* (jointed pipewort), found in Skye, Coll, and a few of the neighbouring islands of the Hebrides, with Connemara in the west of Ireland, and not known elsewhere in Europe. The plant is an inhabitant of North America, its true native country, and has no doubt naturally established itself in our western districts owing to the transport of its seeds thither by the Gulf Stream, still endowed with the power of germination. British vegetation, though European, displays affinities to the botany of different regions of the continent, and may be arranged into several groups, each characterised by the presence of plants typical of a vegetable colonization from a particular continental site.

1. *Asturian Type*, found in the south-west of Ireland, where twelve or more species of plants occur in a wild state, original natives of the Asturias, in the north of Spain.

2. *Armorican Type*, found in the south-west of England, and the south-east of Ireland, where a vegetation occurs not seen elsewhere in the British Isles, but intimately related to that of the opposite coasts of Brittany and Normandy, the ancient Armorica.

3. *Scandinavian* or *Boreal Type*, found in the Highlands of Scotland, distinguishing also more sparingly the mountains of Cumberland and Wales, and in a few instances occurring on those of Ireland. These localities present a vegetation different in every respect from that of the plains, analogous to that of the snow-crowned summits of the Alps, and bearing a still more striking resemblance to the forms which are characteristic of Scandinavian and Arctic lands.

4. *Germanic Type*, found very generally diffused in Great Britain and Ireland, consisting of plants identical as to species with the flora of Central Europe, and composing the predominating vegetation of the kingdom, occurring either alone or in company with the other groups. The well-known chalk-plants, common to the south-east of England, where the rocks of the cretaceous system are principally developed, and to the opposite coasts of France, may be referred to this type.

Horizontal Distribution.—The general phenomena presented by the vegetable productions of the kingdom in their horizontal distribution, mainly influenced by latitude, longitude, soil, exposure, and other conditions of the surface, may be briefly illustrated. A few examples only are given under the several heads of remark.

Species peculiar to the south-west of Ireland, the region of mild winters:

Saxifraga umbrosa (London-pride Saxifrage), so called from being well known in the gardens of London, and from its beautifully spotted flower; called in Ireland St. Patrick's Cabbage, plentiful on the mountains of the south and west; found also in woods at Wetherby and Craven, Yorkshire; likewise near Edinburgh and Glasgow, but not really wild.

Erica Mediterranea (Mediterranean Heath), on Urrisbeg Mountain, in the wild district of Connemara, Galway, and in Erris, Mayo.

Erica Mackaiana (Mr. Mackay's Heath), in Connemara, its only station at present known, besides the Sierra del Peral, in Asturias, where it was discovered in the same year as in Ireland.

Menziesia polyfolia (Irish Menziesia or St. Dabeoc's Heath), abundant in Connemara.

Arbutus unedo (Strawberry-tree), a beautiful evergreen adorning the Lakes of Killarney, the woods of Muckruss Abbey, and Glengariff, near Bantry.

Species peculiar to the south-west of England and the south-east of Ireland, precluded from migrating farther north by the increasing rigour of the climate:

Examples whose range does not extend beyond the south-west of England:

Helianthemum polyfolium (White Mountain Rock-rose), Brean Downs, Somersetshire; Torquay and Baddicombe rocks; rare.

Hypericum linarifolium (Linear-leaved St. John's Wort), Cape Cornwall; banks of the Teign.

Corrigiola littoralis (Sand Strapwort), on Slapham Sands, and near Star Point, Devon; at Helstone, Cornwall.

Polycarpon tetraphyllum (Four-leaved All-seed), coasts of Devon and Dorset; Portland Island.

Bupleurum aristatum (Narrow-leaved Hare's Ear), rocks near Torquay.

BRITISH ISLANDS:—DISTRIBUTION OF PLANTS.

Physospermum Cornuviense (Cornish Bladder-seed), bushy fields in Cornwall; near Bodmin Wood, on the Devonshire side of the Tamar.
Lobelia urens (Acrid Lobelia), very rare: only found near Axminster.
Erica ciliaris (Ciliated Heath), near Truro and Penryn, Cornwall; near Corfe Castle, Dorset.

Examples present in the preceding district, and extended to the south-east of Ireland—

Sibthorpia europæa (Creeping Sibthorpia, or Cornish Money-wort), abundant on Conner Hill, near Dingle, and near Brandon.
Linaria italica (Italian Toad-flax), by the River Bandon, Cork.
Scrofularia scorodonia (Balm-leaved Fig-wort), at Tralee.
Cicendia filiformis (Least Gentianella). near Cork; upon Dursey Island.
Erica vagans (Cornish Heath), islet on the coast of Waterford, near Tramore.

Chalk-plants in the south-east of England, the principal region of the chalk:

Phyteuma orbiculare (Round-headed Rampion), on the downs of Sussex and Hants; in Kent and Surrey.
Ophrys arachnites (late Spider Orchis), downs of South Kent, between Sittingbourne and Folkestone.
Orchis hircina (Lizard Orchis), chalk hills and bushy places in Kent and Surrey.
Orchis militaris (Military Orchis), extending westward into Berks.
Ophrys aranifera (Spider Ophrys), chalk pastures and pits, Kent.

Eastern species, limited to the eastern counties of England, taking the meridian of 2° W. for the division between east and west:

Anemone pulsatilla (Pasque-flower Anemone), in various districts.
Frankenia lævis (Smooth Sea-heath), on the coast from Sussex to Norfolk.
Holosteum umbellatum (Umbelliferous Jagged Chickweed), on old walls about Norwich and Bury.
Artemisia campestris (Field Southernwood), dry sandy heaths in Norfolk and Suffolk.
Melampyrum cristatum (Crested Cow-wheat), woods, thickets, in Norfolk, Cambridge, Huntingdon, and Bedford.
Veronica verna (Vernal Speedwell), about Bury and Thetford, Suffolk and Norfolk.
Veronica triphyllos (Blunt-fingered Speedwell), confines of Norfolk and Suffolk.
Liparis Loeselii (Two-leaved Liparis), sandy bogs, Norfolk, Suffolk, and Cambridge.

Western species, ranging on the west side of England, occurring also in the extreme south, and running up into Scotland, but absent from the east of the island between the Lincolnshire Wash and the Firth of Forth, and mostly absent from the entire east between the Thames and the Murray Firth.

Rubia peregrina (Wild Madder), in the south, running up the west to Caernarvon and Anglesey.
Euphorbia portlandica (Portland Spurge), south, and found on the west shores to Scotland.
Euphorbia paralias (Sea Spurge), south, and west from Somerset to Cumberland.
Raphanus maritimus (Sea Radish), south, and west from Somerset to the Isle of Bute.
Bartsia viscosa (Yellow Viscid Bartsia), south, and west from Cornwall to Argyle.
Pinguicula lusitanica (Pale Butterwort), south, and west from Cornwall to Cape Wrath.
Brassica monensis (Isle of Man Cabbage), on both sides of the Irish Sea; isles and shores of the Clyde.
Carum verticillatum (Whorled Caraway), Wales; near Carlisle; west of Scotland.

Species extended over considerable tracts, or into several districts of England and Scotland, but have not migrated westward into Ireland:

Thalictrum majus (Greater Meadow-rue).
Ranunculus hirsutus (Pale Hairy Crowfoot)
Thlaspi alpestre (Alpine Penny-cress).
Lychnis viscaria (Red German Catchfly).
Stellaria nemorum (Wood Stitchwort).
Genista anglica (Needle Green-weed).
Astragulus hypoglottis (Purple Mountain Milk-vetch).
Spiræa filipendula (Common Dropwort).
Potentilla verna (Spring Cinquefoil).
Ligusticum scoticum (Scottish Lovage).
Valeriana dioica (Small Marsh Valerian).
Scabiosa columbaria (Small Scabious).
Campanula glomerata (Clustered Bell-flower).
Acorus calamus (Common Sweet Sedge).

It is remarkable that certain species which flourish best on limestone, are not found in the limestone districts of Ireland; and in like manner, certain species, which everywhere, when found, delight in sand, are also wanting on such Irish localities as are best adapted for them.—*Forbes' Geol. Survey.*

Species peculiar to single counties, often occurring very locally in them:

Ranunculus alpestris (Alpine White Crowfoot), sides of rills, Clova Mountains	Forfar.
Lychnis alpina (Red Alpine Campion), rocks on summit of Clova Mountains	Ditto.
Oxytropis campestris (Yellowish Mountain Oxytropis), rocks in the Clova Mountains	Ditto.
Potentilla tridentata (Three-toothed Cinquefoil), on Werron Hill, Clova	Ditto.
Saxifraga pedatifida (Pedatifid-leaved Saxifrage), rocks near the head of Clova	Ditto.
Galium aristatum (Bearded Bed-straw)	Ditto.
Galium spurium (Smooth-fruited Corn Bed-straw), cornfields near Forfar	Ditto.
Sonchus alpinus (Blue Alpine Sow-thistle), near rills, Clova Mountains, and other stations	Ditto.
Juncus teneris (Slender Spreading Rush), moist rocks, Clova	Forfar.
Carex hordeiformis (Barley Carex), small valley near Panmure	Ditto.
Arabis stricta (Bristol Rock-cress), St. Vincent's Rocks, near Bristol	Somerset.
Dianthus cæsius (Mountain Pink), limestone rocks at Cheddar	Ditto.
Draba aizoides (Yellow Alpine Whitlow-grass), walls and rocks near Swansea	Glamorgan.
Silene italica (Italian Catchfly), cliffs at Dover	Kent.
Althæa hirsuta (Hispid Marsh-mallow), fields and waste places near Cobham	Ditto.
Verbascum thapsiforme (Thapsus-like Mullein), roadsides	Ditto.
Elymus geniculatus (Pendulous Sea Lyme grass), salt marsh near Gravesend	Ditto.
Ononis reclinata (Small Spreading Rest-harrow), steep bank by the sea	Wigton.
Potentilla rupestris (Strawberry-flowered Cinque-foil), on Craig Breidhin	Montgomery.
Rosa Wilsoni (Wilson's Rose), on a declivity near the Menai	Caernarvon.
Cotoneaster vulgaris (Common Cotoneaster), cliffs at Orme's Head	Ditto.
Anthericum serotinum (Mountain Spider-wort), on Snowdonia	Ditto.
Saxifraga cernua (Drooping Bulbous Saxifrage), dry rocks, Ben Lawers	Perth.
Myosotis alpestris (Rock Scorpion-grass), Breadalbane Mountains	Ditto.
Eriophorum capitatum (Round-headed Cotton-grass), Ben Lawers	Ditto.
Carex ustulata (Scorched Alpine Carex), ditto	Ditto.
Bupleurum aristatum (Narrow-leaved Hare's Ear), rocks near Torquay	Devon.
Lobelia urens (Acrid Lobelia), heathy ground near Axminster	Ditto.
Trichonema Columnæ (Columna's Trichonema), the Warren, Dawlish	Ditto.
Bupleurum falcatum (Falcate-leaved Hare's Ear), Norton Heath, near Ongar	Essex.
Cnicus tuberosus (Tuberous Plume-thistle), copse near Fonthill	Wilts.
Campanula persicifolia (Peach-leaved Bell-flower), woods near Cullen	Banff.
Phyteuma spicatum (Spiked Rampion), about Mayfield and Waldron	Sussex.
Potamogeton acutifolius (Sharp-leaved Pond-weed), marsh ditches	Ditto.
Cyperus fuscus (Brown Cyperus), meadow near Little Chelsea	Middlesex.
Poa laxa (Wavy Meadow-grass), on Ben Nevis	Inverness.
Avena planiculmis (Flat-stemmed Oat-grass), on the ascent of Goat Fell	Arran.

Species limited to the extreme north:

Arenaria norvegica (Norwegian Sandwort), disappearing southwards in Unst, the most northern of the Shetlands.
Primula scotica (Scottish Primrose), frequent in the Orkneys, and on the north coasts of Sutherland and Caithness; formerly supposed to be peculiar, but ascertained to occur abundantly in Norway.

Species prevalent chiefly in Scotland, or the north of England, and becoming rare or disappearing southwards:

Trollius europæus (Mountain Globe-flower).
Andromeda polyfolia (Marsh Andromeda).
Primula farinosa (Bird's-eye Primrose).
Geranium sylvaticum (Wood Crane's-bill).
Rosa rubella (Red-fruited Dwarf Rose).
Salix damascena (Damson-leaved Willow).
Viola lutea (Yellow Mountain Violet).
Corydalis claviculata (White Climbing Corydalis).
Ribes alpinum (Tasteless Mountain Currant).
Sedum villosum (Hairy Stonecrop).
Epilobium angustifolium (Rose-bay Willow-herb).
Pyrola media (Intermediate Winter-green).

Species chiefly or exclusively found in England, and decreasing in frequency northwards:

Acer campestre (Common Maple).
Fagus sylvatica (Common Beech).
Castanea vulgaris (Spanish Chestnut).
Ulmus campestris (Common Elm).
Viola odorata (Sweet Violet).
Pseudo-narcissus (Common Daffodil).
Ornithogalum pyrenaicum (Star of Bethlehem).
Daphne mezereum (Common Mezereon).
Daphne laureola (Spurge Laurel).
Orchis morio (Green-winged Meadow Orchis).
Iris fœtidissima (Stinking Iris).
Taxus communis (Common Black Bryony).
Clematis vitalba (Common Traveller's Joy).
Viscum album (Common Mistletoe).

Species universally, or very widely, spread over England and Scotland, forming some principal components of British vegetation:

Quercus robur (Common Oak).
Ulmus montana (Wych Elm).
Betula alba (Common Birch).
Alnus glutinosa (Common Alder).
Corylus avellana (Hazel-nut).
Populus tremula (Aspen).
Salix fusca (Dwarf Willow).
Taxus baccata (Common Yew).
Prunus spinosa (Blackthorn).
Rubus fruticosus (Blackberry).
Fraxinus excelsior (Common Ash).
Ilex aquifolium (Common Holly).
Anthoxanthum odorata (Sweet-scented Vernal-grass).
Alopecurus pratensis (Meadow Fox-tail Grass).
Bellis perennis (Common Daisy).
Calluna vulgaris (Common Ling).
Ranunculus acris (Upright Meadow Crowfoot).
Capsella bursa-pastoris (Common Shepherd's-purse).
Trifolium repens (White Trefoil).
Rosa canina (Common Dog Rose).

Every plant universally spread over the British Islands is Germanic.—*Forbes.*

Perpendicular Distribution.—Vegetable distribution, in relation to altitude above the sea, presents in a very striking manner within the kingdom the usual pheno-

BRITISH ISLANDS:—DISTRIBUTION OF ANIMALS.

mena of species flourishing on the plains becoming stunted and flowerless on the mountains, failing altogether, and being replaced by other species never found on the low grounds. The best information upon this interesting point will be found in Mr. H. C. Watson's Essay "On the Geographical Distribution of British Plants." His division of the country into ascending botanical zones or regions, is substantially as follows:

Regions.	Characteristic Species.	Altitude in feet.
Plains	Vegetation, consisting of the arborescents, shrubs, weeds, and wild flowers, most familiar to us.	
Uplands	*Quercus sessiflora* (Sessile-fruited Oak)	900
	Fraxinus excelsior (Ash)	1200
	Corylus avellana (Hazel)	1500
	This region marks in general the upper limit of cultivation in England, terminating lower in Scotland.	
Medians	*Cytisus scoparius* (Common Broom)	1800
	Genista Anglica (Needle Green-weed)	2100
Subalps	*Arbutus uva ursi* (Red Bearberry)	2400
	Juniperus communis (Common Juniper)	2700
	Calluna vulgaris (Ling)	3000
Alps	*Azalea procumbens* (Trailing Azalea)	3300
	Vaccinium vitis Idæa (Red Whortleberry)	3600
	Empetrum nigrum (Black Crowberry)	3900
	Vaccinium myrtillus (Bilberry or Whortleberry)	4200
	Salix herbacea (Least Willow)	4350

The altitudes refer specially to the Scottish highlands.

Species distributed over the Scottish highlands, and found also in mountainous districts south of the border:

Cornus suecica (Dwarf Cornel).
Oxyria veniformis (Mountain Sorrel).
Trientalis europæa (European Chickweed).
Rubus chamæmorus (Cloudberry).
Rhodiola rosea (Rose-root).
Silene acaulis (Moss Campion).
Thalictrum alpinum (Alpine Meadow-rue).
Arabis petræa (Alpine Rock-cress).
Cerastium alpinum (Hairy Alpine Chickweed).
Salix reticulata (Reticulated Willow).
Circæa alpina (Alpine Enchanter's Nightshade).
Saxifraga nivalis (Clustered Alpine Saxifrage).
Saxifraga hypnoides (Mossy Saxifrage).
Saxifraga muscoides (Mossy Alpine Saxifrage).
Potentilla alpestris (Orange Alpine Cinquefoil).
Erigeron alpinus (Alpine Flea-bane).
Juncus filiformis (Thread Rush).
Juncus triglumis (Three-flowered Rush).

Species found in the Scottish highlands, but not extended to the English, Irish, or Welsh Mountains:

Draba rupestris (Rock Whitlow-grass).
Saxifraga rivularis (Alpine Brook Saxifrage).
Gentiana nivalis (Small Alpine Gentian).
Veronica alpina (Alpine Speedwell).
Veronica saxatilis (Blue Rock Speedwell).
Salix arenaria (Downy Mountain Willow).
Betula nana (Dwarf Birch).
Arenaria rubella (Alpine Sandwort).
Arbutus alpina (Black Bearberry).
Ajuga pyramidalis (Pyramidal Bugle).
Goodyera repens (Creeping Goodyera).
Corallorhiza innata (Spurless Coral-root).
Pinguicula alpina (Alpine Butterwort).
Juncus trifidus (Three-leaved Rush).

In several cases, the rare Alpine plants of our islands have been rendered still rarer by the ardour of collectors, while an instance of total extirpation has occurred in *Eriophorum alpinum* (alpine cotton-grass), discovered in the Moss of Restenet, Forfarshire, which disappeared upon the draining of the bog, and is certainly extinct.

Flora of the British Seas.—Our marine algæ, as at present known, comprise about 370 species, grouped into 105 genera. They are almost entirely cryptogamic, a class of plants endowed with capacity to endure great vicissitudes of climatal conditions, and therefore, in many instances, very widely spread, ranking as citizens of the world. Some species, however, become plentiful and more luxuriant in the British seas as we travel from north to south, and forms appear on the genial shores of Devonshire which are never observed on the Scottish coasts. On the other hand, several species occur more frequently and in a finer state as we approach the north, and forms are noticed peculiar to the higher latitudes of Great Britain. Accordingly, algolists consider the English and Bristol Channels, with part of the east coast of England, and the south and west of Ireland, as forming a southern region of marine vegetation, characterised by the presence of algæ not found farther north, the absence of southern species, the greater abundance and luxuriance of northern forms, and the presence of other algæ, marking out a northern marine flora on the coasts of Scotland, and of the north of England and Ireland. In the perpendicular distribution of seaweeds, two great zones or regions are noticed by Mr. Forbes, severally denominated the Littoral and Laminarian zones.

Littoral Zone, characterised by the presence of species of the genera *Fucus*, *Lichina*, *Laurencia*, and *Corallina*, is that tract which extends between high and low water marks, depending therefore for its vertical extent upon the amount of rise and fall of the tides.

Laminarian Zone, characterised by the great tangle sea-weeds *Laminariæ*, with other inhabitants of deep water, commences at low water mark, and extends to a depth of from 40 to 90 feet.

Taking the colour for the most obvious character of marine algæ, the following is the order of vertical distribution:—Green sea-weeds, *Chlorospermeæ*, abounding near high water mark, and in shallow tide-pools within the tidal limit; olive-coloured sea-weeds, *Melanospermeæ*, commencing feebly at the margin of high water, increasing in luxuriance with increasing depth, through the zone of exposed rock, but generally ceasing to grow under low water mark; red sea weeds, *Rhodospermeæ*, increasing in numbers and in colour as they are not exposed to the action of the atmosphere.

CHAPTER VIII.

ZOOLOGY.

Our limits render it necessary to exclude from notice the lower forms of animal life, as well as to confine attention mainly to the terrestrial fauna, omitting the races in a state of decided domestication, as not indigenous to the British Islands.

Insecta.—The entomology of the United Kingdom includes a vast number of species, the Irish insects at present known alone comprising about 3850 species. Of the Lepidopterous order (scale-winged, moths and butterflies), nearly 2000 species have been described as British,—of which, however, only about 450 are Irish. The examples wanting in the sister kingdom include many of our most splendid forms, while species common in the south of Ireland are quite unknown in the north. The distribution of insects in general being regulated in a great measure by vegetation, certain classes are restricted to districts where a peculiar flora prevails. The entomology of the south-east of England is intimately connected with the presence of the chalk plants in that region.

Mollusca.—The following arrangement of marine shell-fish found along our coasts, is derived from the valuable essay of Mr. Forbes, *Geological Survey*.

1. *South European Type.*—Species which have the northernmost limits of their range in the southern part of the English Channel. Abundant round the Channel Islands, occasionally taken on the south coast of England, marking the bounds of a fauna which can scarcely be regarded as within our limits.
2. *South British Type.*—Species generally distributed through the English Channel even to the German Ocean, and occupying St. George's Channel to about the line of Cardigan Bay, stretching far up on the coast of Ireland.
3. *West European Type.*—Species generally diffused throughout the seas and shores of the British Isles, which range also generally through the European seas, or at least along the coasts of Western Europe, from Norway to the south of Spain.
4. *Celtic Type.*—Species which have invariably a continued range north of Britain, but their chief development within and around our area.
5. *British Type.*—Species in the British seas not known elsewhere, or else very rare on other coasts, mostly found in the Irish Sea, which appears to have been the centre from which they have radiated.
6. *Atlantic Type.*—Species not generally distributed through the British seas, but commencing at the south-western shores of England, stretching across the south part of St. George's Channel, and continued along the west coast of Ireland to the Hebrides and Shetlands; rarely, if ever, found in the Irish Sea or in the German Ocean.
7. *Oceanic Type.*—Species occasionally found on our Atlantic coasts, visitants drifted thither by storms from the west and south.
8. *Boreal Type.*—Species found on the coasts of Scotland, and the northern shores of England and Ireland, very rare, or almost unknown southwards.
9. *Arctic Type.*—Species found rarely south of the most northerly seas of Britain.

Pisces.—Mr. Yarrell has described and figured 263 species belonging to the rivers, lakes, and seas of the kingdom, several in the latter instance not being constant and characteristic residents, but occasional visitors from northern or southern ichthyological provinces:

PROMINENT OR OTHERWISE REMARKABLE SPECIES.

Salmo salar, salmon, principal fisheries in the Scotch and Irish rivers.
Salmo trutta, salmon trout, most abundant in the Scotch rivers.
Salmo fario, common trout, widely diffused in most rivers and lakes.
Salmo ferox, great lake trout, Lochs Awe, Laggan, Shin, Layghal, and Assynt; Loughs Neagh, Erne, and Corrib; Ulleswater.
Salmo salvelinus, char, deepest part of the lakes of Great Britain and Ireland.
Salmo eperlanus, smolt, east and west coasts of Great Britain, not in the Channel.
Salmo thymallus, local in English and Welsh rivers, not in Scotch or Irish.
Corregonus pollan, pollan or fresh-water herring, Loughs Neagh, Erne, and Derg.

Clupea pilchardus, pilchard, coasts of Cornwall and Devon, three principal stations, between Start Point and the Lizard, between the Lizard and Land's End, and about St. Ives.

Clupea harengus, herring, all the shores; principal fisheries carried on along the east coast, from Wick, Peterhead, Fraserburg, Helmsdale, and Yarmouth.

Clupea sprattus, sprat, most plentiful on the Norfolk, Suffolk, Essex, and Kent coasts.

Clupea alba, whitebait, abounding in, but not peculiar to the Thames.

Morrhua vulgaris, common cod, ranging all round the coasts, but most abundant about the islands north and west of Scotland; principal fisheries carried on near the Orkney and Shetland Isles, and from the Lincolnshire coast to the Nore.

Morrhua æglefinus, haddock, common to all the coasts, but most abundant from Yarmouth to the Tyne.

Rhombus maximus, turbot, rare in the north, but increasing southwards.

Solea vulgaris, sole, sandy shores round all the coasts.

Conger vulgaris, conger eel, rocky parts of the whole coast, especially Cornwall.

Acipenser sturio, sturgeon, various parts of the coasts, most frequently taken in the estuaries.

Scomber scomber, common mackerel, most parts of the coasts.

Perca fluviatilis, perch, common to all rivers and lakes except in the north of Scotland.

Cyprinus barbus, barbel, most abundant in the Thames above London.

Esox lucius, pike, common in almost all rivers and lakes; formerly rare, and supposed not to be indigenous.

REPTILIA.—Out of a total number of 657 species known and described by naturalists, Great Britain possesses only 13, five of which are common to Ireland.

ORDER, SAURIA—LIZARDS; TWO SPECIES.

Lacerta agilis, sand lizard, sandy heaths near Poole; found also in moist situations in the same neighbourhood, at the village of Hamworthy.

Zootica vivipara, viviparous lizard, common on heaths and banks in most parts of England, extending even to Scotland, and one of the few reptiles in Ireland.

The beautiful green lizard of the south of Europe, *L. viridis*, ranges as far north as Guernsey.

ORDER, AMPHIBIA OR BATRACHIA—FROGS, TOADS, ETC.; EIGHT SPECIES.

Rana temporaria, common frog, generally diffused, but probably not known in Ireland before the beginning of the last century.

Rana esculenta, edible frog, first noticed in this country in Foulmire Fen, Cambridgeshire, September, 1843; found also in lakes, Forfarshire.

Bufo vulgaris, common toad, not known in Ireland.

Bufo calamita, natter-jack toad, not commonly met with, but numerous in some localities; neighbourhood of London, and Scottish side of the Solway Firth; found also at Ross Bay in Cork, and in Kerry.

Triton cristatus, great water-newt, common in ponds and ditches.

Triton Bibronii, strait-lipped water-newt, till recently an unknown species.

Lissotriton punctatus, common smooth newt or eft, general in Great Britain and Ireland

Lissotriton palmipes, palmated smooth newt, recently discovered in various parts of Englaud, and the extreme north of Scotland.

ORDER, OPHIDIA—SERPENTS; THREE SPECIES.

Anguis fragilis, blindworm, or slowworm, various parts of England and Scotland.

Natrix torquata, harmless ringed snake, moist woods, damp meadows, Great Britain.

Pelius berus, adder or common viper, common in all parts of England and Wales in sandy wastes and dry heaths, and far more numerous in Scotland than the harmless snake. No snakes occur in Ireland.

The rare occurrence of turtles of three species drifted across the Atlantic by the waves and currents to different parts of our shores, entitle them to no place among British reptilia.

AVES.—Omitting the birds which occasionally arrive as accidental stragglers belonging to the fauna of other countries, with the domesticated breeds, but including the periodical migrants whose journeying to and fro is a part of their natural economy, the number of species amounts to about 274, which may be swelled to between three and four hundred by the addition of the casual visitors.

PROMINENT OR REMARKABLE SPECIES.

Aquila chrysaëtos, golden eagle, mountains of Great Britain and Ireland, but chiefly in the north of Scotland.

Haliaëtos albicilla, white-tailed or cinereous sea eagle, rocky coasts, common in the Hebrides, Orkneys, Shetlands.

Pandion haliaëtos, osprey or fishing-hawk, north-west coast of Scotland most frequent.

Falco islandicus, gyr falcon, least common of the British falconidæ.

Falco peregrinus, peregrine falcon, bold coasts of Devon, Cornwall, Wales, Ireland; but most numerous in Scotland.

Falco æsalon, merlin, North Wales, north of England and Ireland, Scotland and the isles.

Falco tinnunculus, kestrel, of more frequent occurrence in Great Britain and Ireland than any of the falconidæ.

Astur palumbarius, gos-hawk, rare in Great Britain, not known in Ireland.

Accipiter fringillarius, sparrow-hawk, common throughout the kingdom.

Milvus ictinus, kite, rare in England, not known in Ireland as an indigenous bird.

Buteo vulgaris, common buzzard, wooded districts of England, common in Ireland, not plentiful in Scotland.

Circus cyaneus, hen-harrier, general, but nowhere numerous.

Otus vulgaris, long-eared owl, most common in the south and west of England, occurs throughout Ireland.

Strix flammea, white or barn owl, England, Ireland, less numerous in Scotland.

Cinclus aquaticus, dipper or water-ouzel, general where there are upland streams.

Turdus musicus, song-thrush, universally diffused.

Turdus merula, blackbird, very generally distributed.

Accentor modularis, hedge sparrow, generally diffused, but not noticed in the Orkneys and Shetlands.

Erythaca rubecula, redbreast, generally diffused, but more rare in the Shetlands than the Orkneys.

Alauda arvensis, skylark, generally distributed, but only a summer visitor in the Orkneys and Shetlands.

Passer domesticus, house sparrow, common over the whole of the United Kingdom and the inhabited islands.

Coccothraustes chlorus, greenfinch, general in all the cultivated parts of Great Britain and Ireland, but not in the western or northern islands of Scotland.

Carduelis elegans, goldfinch, in numerous localities of England and Wales, certain parts of Ireland, and an inhabitant of the south of Scotland.

Linota cannabina, common linnet, generally distributed.

Pyrrhula vulgaris, bullfinch, general in Great Britain, in certain localities in Ireland, but not found in the Orkneys and Shetlands.

Sturnus vulgaris, common starling, extended over the whole kingdom.

Fregilus graculus, chough, cliffs of the English, Irish, and south Scottish coasts.

Corvus corax, raven, rocky cliffs of all the coasts.

Corvus cornix, hooded crow, north and west of Scotland, visiting England in the winter.

Corvus frugilegus, rook, common to England and Ireland, decreases northwards in Scotland.

Corvus monedula, jackdaw, most parts of the kingdom, not in the Outer Hebrides.

Pica caudata, magpie, common to Great Britain and Ireland; not in the Outer Hebrides, Orkneys, and Shetlands; and established in Ireland since the middle of the sixteenth century.

Picus viridis, green woodpecker, almost all wooded districts of Great Britain, but not in Ireland.

Picus major, great spotted woodpecker, woods of southern and midland England, becomes rare northwards.

Troglodytes vulgaris, wren, generally distributed.

Sitta Europæa, nuthatch, most English woodlands, but rare in the far west and north; not in Scotland and Ireland.

Alcedo hispida, kingfisher, general, but not numerous anywhere.

Columba palumbus, wood-pigeon, wooded parts of the kingdom, but only in the extreme north as a summer visitor.

Columba œnas, stock-dove, eastern and midland counties of England, only in Scotland as a summer visitor.

Phasianus colchicus, common pheasant, introduced from Asia Minor, common over England as far north as Northumberland.

Tetrao tetrix, black grouse, wild parts of the south of England, more numerous in the north, and throughout Scotland.

Lagopus scoticus, red grouse, north of England, Wales, Scotland and the isles, Ireland; but not in any other part of the world except the British Islands.

Lagopus vulgaris, ptarmigan, only found in the highest and wildest parts of Scotland, the Hebrides and Orkneys.

Perdix cinerea, common partridge, generally distributed, but not in the Outer Hebrides.

Otis tarda, great bustard, formerly plentiful on Newmarket Heath and Salisbury Plain, but now nearly extirpated.

Vanellus cristatus, peewit, generally distributed.

Ardea cinerea, common heron, in colonies in various parts of the kingdom; very plentiful in the Orkneys and Shetlands.—Heronries in the English counties:

Berkshire, 2: Windsor Great Park.
Middlesex, 1: Osterley Park.
Essex, 1: Wanstead Flats.
Kent, 2: Cobham Hall; Penshurst Park.
Surrey, 2: Cobham Park; Ashley Park.
Dorsetshire, 1: Brownsea Island.
Devonshire, 3: Powderham Castle; at Sharpham on the Dart; at Warleigh on the Tamar.
Somerset, 2: Brockley Woods; Picton.
Salop, 1: at the Mere, near Ellesmere.
Lincoln, 4: Skellingthorpe Wood; Manby; Downington; near Cressy Hall.
Norfolk, 1: Didlington.
Northampton, 1: Althorpe Park.
Warwick, 1: Warwick Castle.
Durham, 1: Ravensworth Castle.
Westmoreland, 1: Delham Tower.
Northumberland, 1: Chillingham Park.
Yorkshire, 3: Walton Hall; Hutton, near Beverley; near Boroughbridge.
Cumberland, 2: Gowbarrow Park; Graystock.
Cheshire, 5: Dunham Massey; Combermere Abbey; Hooton-on-the-Mersey; Ardley Hall; Oulton Park.

Anas boschas, wild duck, general, but more numerous formerly than at present.

Somateria mollissima, eider duck, north of Great Britain, not ranging to England except in winter.

Phalacrocorax carbo, common cormorant, rocky parts of all the coasts.

Sula alba, gannet or solan goose; principal breeding stations: Lundy Island, off the coast of Devon; Skelig Isles, off the coast of Kerry; Isle of Ailsa, Firth of Clyde St. Kilda; Souliskerry, near the Orkneys; Bass Rock, in the Firth of Forth.

BRITISH ISLANDS:—DISTRIBUTION OF ANIMALS.

BIRDS OF PASSAGE.

Summer Visitors.

Lanius collurio, red-backed shrike, a summer visitor to England, not reaching Ireland or Scotland.

Muscicapa grisola, spotted fly-catcher, common in summer in England and Ireland, rare in Scotland.

Turdus torquatus, ring ouzel, arriving from the south, distributed generally over the mountainous districts of Great Britain and Ireland, but not noticed in the Orkneys or Shetlands.

Sylvia luscinia, nightingale, from the south, appears in April, the males preceding the females by about a fortnight. It is by no means generally distributed. It does not frequent Wales, or the S.W. angle of England, or range higher than five miles north of York. It is consequently absent from Scotland and the adjoining islands, and is altogether unknown in Ireland.

Oriolus galbula, golden oriole, from Africa, occasionally appears in the south of England and in Ireland.

Phœnicura ruticilla, redstart, from the south, ranging to the extreme north of Scotland, but rare in some localities, and only once obtained in Ireland.

Saxicola œnanthe, wheatear, general over England, Wales, Ireland, Scotland, and the islands.

Curruca atricapilla, blackcap, from the south and east, visits England and Wales generally, some parts of Scotland, but not noticed in the islands, and only obtained once in Ireland.

Yunx torquilla, wryneck, from the east and south, visits the S.E. of England, rare westwards and northwards, not observed in Ireland.

Cuculus canorus, common cuckoo, general over the whole kingdom.

Hirundo rustica, swallow, common throughout the British isles.

Hirundo urbica, martin, as general as the swallow, but usually comes a few days later.

Hirundo riparia, sand martin, generally but locally distributed.

Crex pratensis, landrail, generally distributed.

Winter Visitors.

Turdus pilaris, fieldfare, a winter visitor to Great Britain and the north of Ireland.

Turdus iliacus, redwing, from N. and N.E. parts of Europe, arriving earlier than the fieldfares.

Scolopax rusticola, woodcock, general, some remaining through the year.

Scolopax gallinago, common snipe, many remaining in the northern parts through the year.

Anas segetum, bean goose, common in Great Britain and Ireland, but more rare on going southward.

Cygnus ferus, hooper, or whistling swan, descending to the southern parts of England in severe weather.

Colymbus glacialis, great northern diver, plentiful in the Orkneys and Shetlands, decreasing southerly.

Remarkable Stragglers.

Vultur fulvus, griffon vulture, Alps and Pyrenees, caught near Cork Harbour, 1843.

Neophron Percnopterus, Egyptian vulture, shot in Somersetshire, 1825.

Nauclerus furcatus, swallow-tailed kite, from the southern states of North America, taken in Argyleshire, 1772, and in Yorkshire, 1805.

Aquila nævia, spotted eagle, inhabitant of the Apennines, shot in Cork county, 1845.

Turdus aurigaster, gold-vented thrush, native of South Africa, shot near Waterford, 1838.

Alauda alpestris, shore lark, inhabits the northern regions of the globe, but most plentiful in North America, shot in Norfolk, 1830.

Agelaius phœniceus, red-winged starling of America, taken near Yarmouth and London, 1842, 1844.

Cuculus glandarius, great spotted cuckoo, inhabits North Africa, taken in Galway, 1843.

Larus Bonapartii, Bonapartian gull, fur countries of North America, taken near Belfast, the only individual of the species known to have visited Europe.

NUMBER OF SPECIES OBSERVED IN THE FOLLOWING LOCALITIES:

Kensington Gardens, London, nearly	70
Site near Belfast, 75 English acres in extent	70
Selbourne parish, comprising an extent of 30 miles in circumference	120
Same circuit around Belfast, principally maritime	185

The influence on birds of the difference in climate between Great Britain and Ireland, is stated by Mr. Thompson to be, that in the north of Ireland, owing to the comparative mildness of the winter, a few land species, considered as birds of passage in England, except in the extreme south, become resident, and some grallatorial birds remain, although found only in the south of England at this season. The soft-billed birds, also, being generally able to procure abundance of food, are, by the comparatively high temperature, more inclined to song at this period of the year.

MAMMALIA.—Professor Bell enumerates between 80 and 90 species belonging to the mammiferous fauna of the kingdom, little more than a third of which are Irish; but his list includes the domesticated animals which are excluded from the following catalogue, with others of such rare occurrence, solitary examples in some instances, as to come into the category of accidental wanderers.

ORDER, CHEIROPTERA—BATS.

Vespertilio noctula, great bat, resorts to hollow trees.

Vespertilio pipistrellus, common bat, resorts to crevices of buildings.

Vespertilio serotinus, serotine, found around London, its only known British locality.

Vespertilio Nattereri, reddish grey bat, near London, Swaffham, Norwich, Colchester, Chiselhurst.

Vespertilio Daubentonii, Daubenton's bat, Islington, Milton Park, Northamptonshire.

Vespertilio mystacinas, whiskered bat, Cambridgeshire, Northamptonshire, Colchester, Chiselhurst.

Plecotus auritus, long-eared bat, one of the most common British species.

Plecotus barbastellus, the barbastelle, a bat taken in the counties of Kent, Devon, Cambridge, and Northampton.

Rhinolophus ferrum equinum, greater horse-shoe bat, many English localities.

Rhinolophus hipposideros, lesser horse-shoe bat, Wiltshire, Kent's Cavern, Torquay.

ORDER, INSECTIVORA—INSECT-EATING ANIMALS.

Erinaceus Europæus, common hedgehog.

Talpa vulgaris, common mole, not in any part of Ireland, or north extremity of Scotland.

Sorex araneus, shrew mouse, common in dry situations.

Sorex fodiens, water-shrew, various parts of England and Scotland.

Sorex remifer, oared-shrew, near Glasgow, Norfolk, Battersea Fields.

ORDER, CARNIVORA—FLESH-EATING ANIMALS.

Meles taxus, badger, many parts of Great Britain, but rare, the only surviving representative of the bear family in the kingdom.

Lutra vulgaris, common otter, rare in England, frequent in Wales and Scotland, marine in its habits in the north of Ireland and the Shetlands.

Mustela vulgaris, common weasel, general.

Mustela erminea, ermine weasel or stoat, general, changing its colour in the north to snow-white.

Mustela putorius, fitchet weasel or polecat, general.

Martes foina, common marten, general in forest districts.

Martes abietum, pine marten, frequent in the pine forests of Scotland.

Felis catus, wild cat, woods in the north of England, woody mountains of Wales, some parts of Ireland, most frequent in Scotland.

Vulpes vulgaris, common fox, generally distributed.

Phoca vitulina, common seal, abounds on the northern shores and islands of Scotland.

ORDER, RODENTIA—GNAWING ANIMALS.

Sciurus vulgaris, common squirrel, woods of Great Britain, not indigenous in Ireland, but recently introduced into the county of Wicklow.

Myoxus avellanarius, common dormouse, not in Ireland.

Mus messorius, harvest mouse, south of England, probably not in Ireland.

Mus sylvaticus, long-tailed field mouse, scattered over the whole kingdom.

Mus musculus, common mouse, universally distributed.

Mus rattus, black rat, old houses of large cities, an introduced species now become rare.

Mus decumanus, brown rat, an introduced species, generally distributed.

Arvicola amphibius, water vole, banks of almost all streams, not in Ireland.

Arvicola agrestis, field vole or meadow mouse, not known in Ireland.

Arvicola pratensis, bank vole, south of England, not in Ireland.

Lepus timidus, common hare, general in Great Britain, not in Ireland.

Lepus variabilis, Alpine hare, north of Scotland, occasionally found as far south as the mountains of Cumberland, identical with *lepus Hibernicus*, the Irish hare, formerly supposed to be a distinct species.

Lepus cuniculus, rabbit, generally diffused.

ORDER, RUMINANTIA—RUMINATING ANIMALS.

Cervus elaphus, red deer or stag, Dartmoor, Devonshire, mountains of Scotland, retired localities in Ireland, Glen Veagh, Donegal.

Cervus lama, fallow deer, in parks.

Cervus capreolus, roebuck, rare in England, abound in many parts of Scotland, not in Ireland.

Bos scoticus, wild oxen, in a few parks, probably descended from a domesticated race allowed to run wild.

Capra hircus, common goat, a few wild in Wales.

ORDER, CETACEA—WHALES, ETC.

Phocæna communis, common porpoise, general in the British Seas.

Phocæna orca, grampus, frequent about the northern islands of Scotland, occasionally descending to the English coasts.

Phocæna melas, caaing whale, numerous about the Orkneys and Shetlands, occasionally straggling southward.

Physeter tursio, high-finned cachalot, a spermaceti whale, frequent about the Shetlands in summer.

Balæna mysticetus, common or Greenland whale, occasional about the Shetlands, more frequent formerly.

Rorqual, fin-backed whale, largest of all the whales, often seen about the Northern Islands.

The beaver, wild boar, bear, wolf, and reindeer, formerly inhabited the kingdom; and probably the totally extinct species of deer, commonly called the Irish elk, whose remains have been found in Ireland, the Isle of Man, and England, lingered in Ireland to the current epoch of the animal creation.

CHAPTER IX.

MINERALOGY.

M. Burat expresses the proportionate mineral produce obtained from the different countries of Europe, by the following figures:—

British Isles	1000	Spain	125
Russia and Poland	285	Sweden and Norway	123
France	250	Prussia	111
Austria	154	Belgium	91
German Confederation	143		

Metalliferous Minerals.—The ores not found so abundantly in the United Kingdom as to be worth working on their own account, are chiefly those of gold and silver. Gold is occasionally met with in the tin stream-works of Cornwall. Its other localities are the Lead Hills, in south Scotland; the Breadalbane estate, near Glen Quoich, Perthshire; and the alluvial soil in the Wicklow mountains of Ireland. A small varying percentage of silver usually accompanies galena, a rich sulphuret of lead, hence called argentiferous galena; and it is often worth while to separate the silver by exposing the argentiferous lead to a high temperature. The largest proportion has been found in the Beer Alston mines in Devonshire, which have yielded from 80 to 140 ounces of silver per ton of lead. Only the important products, with principal localities, are here mentioned.

Iron.—Argillaceous or clay-ironstone, the most common variety of ore, occurs regularly bedded in most of the coal formations; in S. Wales, around Merthyr Tydvil; S. Stafford, around Dudley; and E. Salop, Coalbrook Dale, the chief districts in South Britain; W. Riding of York; Derbyshire; N. Wales; Forest of Dean, Gloucestershire; W. Scotland, counties adjacent to Glasgow; E. Scotland, Linlithgow and Fife; abundant also, but neglected, in the coal formations of Ireland. The same ore characterises the upper portion of the oolites in the south-east of England, the Wealds of Kent, Surrey, Sussex, and Hants, where iron was formerly made in considerable quantities. Rich hæmatite, or red iron-ore, traverses in a thick vein the mountain limestone near Ulverstone in N. Lancashire; and Alston Moor, Cumberland, Derbyshire and Cornwall, are well known localities for iron pyrites, a combination of iron and sulphur.

Copper.—Cornwall and Devon; Parys Mountain, Anglesey, discovered in 1768; parts of Wales; Ecton Hill, Staffordshire, the year 1780 its most productive period; counties of Cork and Kerry, Ireland. Cornwall is the great repository. Copper pyrites, a bisulphuret, is the principal ore, next to which is the sulphuret, or gray copper ore. Amount of ore raised in Cornwall and Devon in 1847, 155,985 tons; produce, 12,754 tons of copper; value £889,287.

Tin.—Cornwall and Devon. The common ore is the peroxide, found in veins traversing the granite and slate rocks, or as stream-tin, which consists of small fragments occurring in low grounds, the alluvial debris of tin veins separated from the deposit of gravel or sand by washing. The Cornish tin and copper mines which have been worked upwards of twenty years amount to 35; under twenty years but above ten, 40; under ten years but above five, 31; less than five years, 114.

Lead.—East and West Allendale, Weardale, and Teesdale, Northumberland and Durham; Peak of Derbyshire; Alston Moor, Cumberland; Cornwall and Devon; Swaledale and Arkendale, Yorkshire; Snailbeach, Salop; Cardiganshire and Flintshire, Wales; Isle of Man; Wood Head, Caernsmore, and Lead Hills, South-western Scotland; counties of Wicklow, Down, Limerick and Waterford, Ireland. Amount of ore raised in the British Isles in 1847, 83,747 tons; lead yielded, 55,703 tons.

Zinc.—Obtained in most of the lead districts from ores accompanying the lead. The two most commonly worked are *blende*, a sulphuret of zinc, the "black-jack" of the miners, occurring chiefly in Derbyshire, Cumberland, and Cornwall; and *calamine*, a carbonate, in the Mendip Hills, Derbyshire Peak, Alston Moor, Wanlock Head, and Lead Hills.

Manganese.—Devonshire, Cornwall, Hartshill near Coventry.

Combustible minerals:

Graphite.—A carburet of iron, improperly called blacklead, at Borrowdale, Cumberland.

Anthracite.—Non-bituminous mineral coal, burning without flame or smoke; in S. Wales coal basin, when small, commonly called culm; S. Stafford, stone-coal; Ayrshire and other parts of Scotland, blind-coal; Kilkenny, Ireland. Superficial area occupied by anthracite in the British Isles, estimated at 3720 square miles.

Bituminous coal.—Total area occupied in Great Britain and Ireland, estimated at 8139 square miles; annual production, 31,500,000 tons.

PENNINE COAL DISTRICT, NORTH OF THE TRENT.

Field of Northumberland and Durham, extending from the river Coquet on the north, nearly to the Tees on the south, the most important tract, intersected by two navigable rivers, the Tyne and Wear, and divided into two unequal parts by a great *fault* crossing the district a little north of the Tyne, called the Main Dyke, or Ninety Fathom Dyke, because the strata on the north side are thrown down, or elevated on the south side, by a perpendicular distance of 90 fathoms. The district stretches about 48 miles north and south by an extreme breadth of 24 miles from the coast, the coal beds being prolonged eastwards beneath the bottom of the sea above Shields.

Field of Whitehaven, on the west coast of Cumberland, extends from near Egremont on the south to Allonby on the north.

Field of North Lancashire, between Lancaster and Ingleton.

Fields of North Yorkshire, small insulated basins around Middleham and Leyburn.

Field of South Yorkshire, Nottingham and Derby, extends from the north-east of Leeds to a little to the north of Derby, upwards of 56 miles by a greatest width of 23.

Field of South Lancashire, stretching from the north-west of Derbyshire by Manchester and Rochdale, north to Colne, and north-west to Preston.

Fields of North Staffordshire, two detached, the Pottery coal-field, north-east of Newcastle-under-Lyme, and an insulated basin near Cheadle.

CENTRAL COAL DISTRICT OF ENGLAND.

Field of Ashby-de-la-Zouch, an irregular dislocated area north-west of Leicester.

Field of Warwickshire, running from the east of Coventry to near Tamworth.

Field of South Staffordshire, extending from near Rugeley to near Stourbridge, about 20 miles, having its greatest breadth from Walsall to Wolverhampton, about 7 miles.

WESTERN COAL DISTRICT OF ENGLAND AND WALES.

Field of Anglesey, a valley crossing the island from north to south.

Field of Flintshire, extends, but not continuously, from Llan Asaph, near the west cape of the Dee estuary to near Oswestry.

Field of Coalbrook Dale, on the Severn, east of the Wrekin.

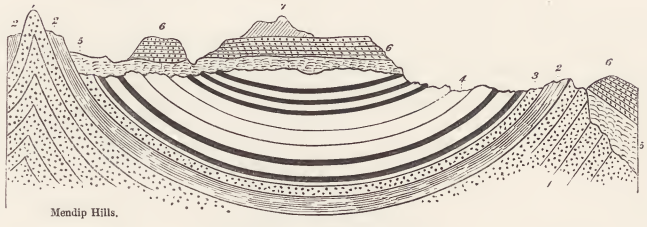
Field of the Plain of Salop, small detached patches west of the Wrekin, and in other parts of the county.

GREAT SOUTH WESTERN COAL DISTRICT OF ENGLAND AND WALES.

Field of South Wales, extends through the principality from St. Bride's Bay on the west, to Pontypool on the east, a distance of upwards of 100 miles, the breadth averaging 18 miles in the central parts.

Field of the Forest of Dean, between the Wye and the Severn.

Field of South Gloucester and North Somerset, bounded by Bristol on the west, Bath on the east, the Mendip Hills on the south, and Tortworth on the north, divided by the Avon into two unequal parts; that on the north being the most extensive. The annexed section of this field offers a good example of the concave bending or basin-shape of the strata, omitting disturbances and dislocations, a common arrangement of coal measures of immense utility as rendering them more accessible to man.



SECTION OF THE BRISTOL COAL FIELD.

1. Old red sandstone.
2. Mountain limestone.
3. Millstone girt.
4. Coal measures.
5. New red sandstone.
6. Lias.

Superior Oolite.

In Scotland, the coal formation extends across the island from south-west to north-east, or from the coast of Ayrshire to Fifeness; also through the Lothians, south and east of Edinburgh; small insulated tracts occurring in the counties of Berwick, Roxburgh, and Dumfries

In Ireland, coal occurs in Kilkenny, Carlow, Queen's County, Tipperary, Clare, Limerick, Cork, and Kerry in the south; also in Antrim, Tyrone, Monaghan, and Roscommon in the north; but the quality is inferior, and the workable fields are of unimportant extent.

PALESTINE AND ADJACENT COUNTRIES.

Lignite.—Brown coal, occurs in a tertiary deposit near Bovey Tracy, in east Devon, formerly extensively worked; also in upper oolitic strata near Kimmeridge, on the coast of Dorset; and in the lower oolites of Brora, on the east coast of Sutherland.

Jet.—On the Yorkshire coast, near Whitby, in aluminous shale.

Amber.—Occasionally met with in beds of gravel near London, and on the coasts of Norfolk and Suffolk.

Earthy mineral aggregates, or rocks, of important economic use:

Granite.—Cornwall, Devon, Cumberland; Highlands of Scotland, and Isle of Arran; Mourne Mountains. The reddish-coloured granite of Aberdeenshire, and the white variety of Cornwall, are extensively quarried for bridges, docks, and public buildings. The coping-stones of Waterloo-bridge, London, exhibit the former; the balustrades the latter.

Sienite.—Malvern Hills; Charnwood Forest, Leicestershire; locally used for road-making.

Gneiss.—The prominent and fundamental rock of great part of the north of Scotland, and the outer Hebrides; employed for building and flagging.

Mica Slate.—Central Scotland; west and north-west of Ireland; a valuable flagging material, varieties furnishing whetstones and fireslabs.

Clay Slate.—Devon, Cornwall, and Cumberland; north Wales; south Scotland; Isle of Man; south Ireland; quarried for roofing-slate, extensively at Penrhyn, near Bangor.

Noble Serpentine.—Isle of Man, and near Portsoy, Banffshire. The latter locality supplied the palace of Versailles with some of its ornaments.

Fluor Spar.—Cumberland, Derby, and Cornwall,—the "Blue John" of miners.

Mountain Limestone.—North of England; north and south Wales; Mendip Hills; central Ireland; often susceptible of a high polish, and formed into blueish gray marble slabs for chimney-pieces, and ornamental works. Near Kilkenny, the limestone passes into a fine black marble, extensively quarried and manufactured into tombstones, vases, &c. The shafts of four Ionic columns, supporting the hall at Besborough, are each formed of a single block of this marble upwards of ten feet in height.

Millstone Grit.—North of England; mountains about Enniskillen, Ireland; often used for millstones. Sandstones, associated with the grit, supply the material of many buildings in the northern counties; Durham Cathedral; Eccleston Abbey, Yorkshire; keep of Richmond Castle; and modern erections in the towns of the district, Newcastle, Durham, and Leeds.

Magnesian Limestone.—From the Tyne southwards, towards Derby and Nottingham; long used, but not extensively for building purposes; York Cathedral, Beverley Minster, and Westminster Hall, built from the quarries near Tadcaster; Roche Abbey, near Bawtry, from quarries in the neighbourhood; the new Houses of Parliament from the Bolsover Moor quarries, Derbyshire.

Oolitic Limestone.—Portland-stone, Isle of Portland, Dorsetshire, used in St. Paul's Cathedral, the Reform Club-House, and Goldsmiths' Hall; Bath-stone, from that neighbourhood, the material of the Abbey Church of Bath, Glastonbury Abbey, and a vast number of modern erections; Ketton-stone, Rutlandshire, used in Ely and Peterborough Cathedrals, also largely at Cambridge; Stonesfield-slate, a fissile limestone, extensively obtained at Stonesfield, Oxfordshire, and used in the place of slate; Sussex and Purbeck marbles, shelly limestones of the Weald, employed by the architects of the middle ages for decorative purposes.

Oolitic Sandstone.—Coast of Yorkshire, near Whitby, used in Whitby Abbey, and shipped to various parts of England.

Alum Shale.—In the lias formation near Whitby, from which the alum of commerce is prepared.

Gypsum.—In the new red sandstone of Cheshire and Derbyshire, the peculiar form of it known as alabaster, wrought into columns and ornaments, occurring near the Trent, in the latter county.

Fuller's Earth.—At Nutfield, near Reigate; Midford Hill, near Bath; and other places.

Kaolin.—The porcelain clay of China, obtained near St. Austle, Cornwall.

Rock Salt.—Near Northwich, Cheshire, in the new red sandstone.

Mineral Springs:

Saline Waters.—Variously impregnated with saline compounds, at Epsom, Cheltenham, Bath, Bristol, Buxton, Leamington, and Matlock; Dumblane and Airthrey near Stirling, Pitcaithley near Perth, and Innerleithen near Peebles; Mallow in Cork. Brine springs, yielding common salt, occur in various places, at Shirleywich in Staffordshire; Droitwich, Worcestershire; Builth, Brecknock; but most extensively in the valley of the Weaver, the rock-salt region of Cheshire.

Chalybeate Waters.—Containing variable quantities of iron, at Tonbridge, Cheltenham, Great Malvern, Harrowgate, Brighton, and many other localities; Bonnington near Edinburgh; Vicar's Bridge near Dollar, and Hartfell near Moffat; Castle Connell near Limerick.

Sulphureous Waters.—Containing hydrosulphuric acid, at Harrowgate, Cheltenham, and Leamington; Strathpeffer near Dingwall, and Moffat Dumfriesshire; Swanlingbar in Cavan, and Lucan in Dublin.

The Malvern waters, commonly considered medicinal, are chiefly characterised by extreme purity.

Though far removed from the regions of powerful volcanic excitement, several of the mineral waters are in varying degrees thermal, all rising through strata of the carboniferous system, mostly below the coal, or through others which rest unconformably upon them, exhibiting remarkably the prevalence of nitrogen among the gases evolved. The following notices are chiefly from Dr. Daubeny's "Essay on Thermal Waters."

WARM SPRINGS OF THE BRITISH ISLANDS.

Bath.—Hot Bath, temperature 117°, King's Bath, 114°, Cross Bath 109°. The King's Bath rises through lias, at a temperature of 66° above that of the neighbourhood; contains saline ingredients, 15 grains in a pint, (muriate of lime and magnesia;) evolves 96·5 per cent. nitrogen, 3·5 oxygen, and some carbonic acid.

Bristol.—Hot Well rises in carboniferous limestone at a temperature of 74°, or 23° above that of the place; contains saline ingredients, 6 grains in a pint, (sulphate of soda and muriate of lime;) evolves 92 per cent. nitrogen, and 8 oxygen.

Buxton.—St. Anne's Well rises in carboniferous limestone, at a temperature of 82°, which it never varies, or 33° above the vicinity; contains saline ingredients, only 1·8 grains in a pint (muriates of magnesia and soda); evolves nitrogen only.

Bakewell, Derbyshire.—Bath spring rises in carboniferous limestone, at a temperature of 13° above the vicinity; contains saline ingredients, 3½ grains in a pint, (sulphate of lime and muriate of soda;) evolves nitrogen only.

Stoney Middleton, Derbyshire.—Spring rises in carboniferous limestone, at a temperature of 14° above that of the vicinity; contains saline ingredients, 2 grains in a pint, (sulphate of soda and magnesia, and muriate of lime;) evolves nitrogen only.

Matlock.—Springs merely tepid, temperature from 66° to 68°.

Taafe's Well, near Cardiff.—Rises from coal strata, at a temperature of 21° above that of the vicinity; contains saline ingredients, only 1·2 grains in a pint, (sulphate of magnesia;) evolves 96½ per cent. nitrogen, and 3½ per cent. oxygen.

Mallow, Co. Cork.—Spa well rises in carboniferous limestone, at a temperature of 23° above that of the vicinity; contains saline ingredients, only 0·3 grains in a pint, (carbonate of lime;) evolves nitrogen 93½ per cent., and oxygen 6½.

No thermal springs occur in Scotland, and their northern limit in England is the Derbyshire Peak.

PALESTINE AND ADJACENT COUNTRIES.

The countries bordering on the eastern shores of the Mediterranean, largely included in the accompanying map, appropriately styled the Lands of the Bible, have been selected for graphic delineation, as the source of our religious faith and the earliest fountain of our historical knowledge. The region represented comprises great part of ancient Syria, all Palestine, the Petræan Arabia, and Lower Egypt.

Astronomical Position.—Between 27° 40′ and 34° 50′ N. lat.: 30° 40′ and 36° 50 E. long.

Mountains and Valleys.—The east coast of the Mediterranean, at a varying distance from the sea, is occupied by a mountain range, which follows the general direction of the meridian, intersecting Palestine from north to south, spreads its ramifications eastward and westward, enters Arabia Petræa, and terminates on the northern shores of the Red Sea. This range is the southern prolongation of a diverging branch from the great chain of Taurus, which lies beyond our limits, but which in common with all the mountains of western Asia, appears to have a kind of central point and grand nucleus in the highlands of Armenia.

About lat. 34° 30′, the mountain system of Syria forms two parallel ridges, the western being the far-famed Lebanon, whose towering summits are discovered by the mariners of the Mediterranean from the sea around Cyprus; and the eastern, the Anti-Lebanon, overlooking eastward the great plains of the desert stretching out towards the Euphrates. They inclose between them the peculiar district known to the ancients as Hollow Syria (Cœle-Syria), a beautiful and narrow longitudinal valley, renowned for the magnificent remains of Baalbec, the water-parting between the Orontes, which flows to the north, and of the Leontes, proceeding to the south, occurring towards the centre. Lebanon has the greatest general elevation; but Anti-Lebanon, at its south extremity, appears to have the highest point.

	Feet.
Jebel Makmel, Lebanon, S.S.E. of Tripoli	9375
Pass immediately to the north	7624
Site of the Cedars	6200
Jebel Sanin, N.E. of Beirout	9350
Town of Baalbec, W. slope of Anti-Lebanon	3700
Jebel-esh-Sheikh (Mount Hermon), S. extremity of Anti-Lebanon, N. frontier of Palestine, overlooking the plain of Damascus, the culminating point of Syria	10,000
Damascus, E. slope of Anti-Lebanon	2420

The term Lebanon is applied indifferently in the Scriptures to both ranges.

The western range, declining in height further south, terminates on the coast,

at the mouth of the Leontes, a little to the north of ancient Tyre. The eastern range, or Anti-Lebanon, divides into two branches, which extend from the southern slopes of Hermon through the whole of Palestine. They bound the singular valley of the Jordan, occupy the country on each side with offsets, inclosing fertile plains and valleys in the north-west, the region of ancient Galilee and Samaria, but surround the basin of the Dead Sea in the south with a network of bare rocks, deep ravines, and frightful precipices.

Cis-Jordanic District.	Feet.
Mount Tabor, S.W. of the Lake of Tiberias	1800
Little Hermon, ditto	1862
Hill of Nazareth, ditto	1237
Ridge of Gilboa, ditto	1300
Convent on Cape Carmel, Bay of Acre	490
Range of Carmel, highest point	1726
Mount Ebal, N. of Nablous (Shechem)	2500?
Mount Gerizim, S. of Shechem	2500
Shechem, in the intervening valley	1700
Mountains of Ephraim	2500
Mount of Olives	2398
Hill of Bethlehem	2705
Hill of Hebron	3029
Mountains of Judah	3000
Trans-Jordanic District.	
Mountains of Gilead	4000?

The Ghor, or Valley of the Jordan, extends about 170 miles from the sources of the river to the south extremity of the Dead Sea, the breadth varying much, but acquiring nowhere any considerable expansion, though gradually opening wider as it approaches the Asphaltic Lake. That part of it which lies between the two principal lakes, to which the title El-Ghor, *the Valley*, is particularly applied, comprises a direct distance of about 65 miles. On the eastern side, the inclosing cliffs are bolder and more continuous than on the western, and present many steep escarpments rising up from the brink of the river; but a fertile plain extends on the opposite side, between its borders and the mountains. The valley is quite a phenomenon in physical geography, on account of its depression below the level of the sea; only another great example of which is known, that of the country bordering on the Caspian, where the depression is comparatively inconsiderable. It amounts at the Dead Sea to 1312 feet below the level of the Mediterranean. Southwards from the Dead Sea the Ghor is prolonged to the Gulf of Akaba, the north-eastern prong of the Red Sea, under the name of Wady-el-Arabah, between the mountains of Seir, containing the summit of Mount Hor on the left, and bordering heights on the right. This was formerly deemed an ancient outlet of the Jordan and the Asphaltic Lake; but an outlet in that direction under existing circumstances is impossible, the Wady-el-Arabah exhibiting two distinct slopes, one ascending from the Dead Sea to El-Satch, and another descending from thence to the Gulf of Akaba, the ridge line forming the water-parting at El-Satch being at least 1200 feet above the Dead Sea, and 500 feet above the Gulf of Akaba. The depression of the Valley of the Jordan is the grandest geological phenomenon in the world, and it may probably be accounted for in a geological manner,—the sinking of the land at one point and its elevation at another by volcanic or similar agency.

The hills which form the western border of the Wady-el-Arabah, in the southern prolongation, enter the peninsula of Sinai, a region of deserts and mountains renowned in Biblical history. It consists of a triangular area, bounded on the east by the Gulf of Akaba, on the west by the Gulf of Suez, and on the north by the nearly level but elevated plains of the ancient wilderness of Paran. A chain of hills extends in a curvilinear line between the heads of the two gulfs, intersecting the peninsula from east to west, and dividing it into two parts, northern and southern. This chain, with the country northward, bears the name of Et-Tyh, or *the wandering*, in commemoration of the wanderings of the Israelites. Consisting of soft chalky strata, sometimes passing into hard limestone, it is geologically distinct from the country southward, or the proper region of Sinai, which is extensively covered with bold dark masses of granite, porphyry, gneiss, and other crystalline rocks. This primitive highland district contains the remarkable site, not certainly identified, emphatically styled in sacred history "The Mount of God."

	Feet.
Jebel Edjme range of Et-Tyh	4645
Convent of St. Catharine	5451
Jebel Serbal, the Sinai of Professor Lepsius and Dr. Kitto	6753
Jebel Mousa, *Mount Moses*, the Sinai of tradition	7560
Jebel Katherin, *Mount St. Catharine*, Horeb of Rüppell	8705
Jebel om Shomar, culminating point of the peninsula	8850

The mountains of Moses and St. Catharine are twin summits rising up from the same elevated platform, which now bears the name of Horeb, at the base of which is the convent.

The features which the general aspect of Lower Egypt presents, consist of a triangular alluvial plain, almost a dead level, forming the Delta of the Nile, intersected by its two great branches, and extending inland from its mouths to the neighbourhood of Cairo; the long narrow valley of the river, which has an average breadth of eight or ten miles; and a country on both sides of the valley, composed of sandy plains and barren rocky mountains, rising to the height of 6000 feet on the borders of the Gulf of Suez, opposite to the peninsula of Sinai.

Seas.—The maritime countries border the east and south shores of the Mediterranean,—the Great Sea of the Hebrews, a denomination which betrays their limited maritime knowledge,—and the north extremities of the Red Sea. The two basins closely approximate, the breadth of the intervening Isthmus of Suez amounting to 378,844 French feet, or about 75 miles. They differ in their level, the surface of the Mediterranean being about 30 feet lower than that of the Red Sea in the Gulf of Suez. (See p. 38.) This gulf, and that of Akaba, bounding the Sinaitic peninsula, may be briefly noticed.

Gulf of Suez.—The western inlet; length about 150 miles: mean breadth, 30, narrowing greatly at the north extremity; mean depth, from 8 to 14 fathoms. Neither its present limits nor depth coincide with those which it appears to have had in ancient times. The gulf has acquired historic importance from its passage by the Israelites, and their subsequent descent on its eastern shore. The point at which that passage took place cannot be precisely identified, and it is even possible, from the former greater extent of the gulf northward, that the site has been incorporated with the isthmus. Not one of the names mentioned (Exod. xiv. 2) now exists. On the east coast the encampment at Marah (xv. 23) is fixed with tolerable certainty at Ain Howara, the site of a bitter well, a few miles south of the bed of a winter torrent, bearing the name of Wady Amarah, which has the same sound and meaning as Marah. The next station, Elim (xv. 27), is probably the present Wady Gharendel, about seven miles south of Howara, a valley of date-trees and acacias, with a spring and rivulet.

Gulf of Akaba.—The eastern inlet: length about 100 miles; breadth from 10 to 15 miles; depth in places, upwards of 200 fathoms; shut in by lofty granitic mountains rising from the seaside 2,000 or 2,500 feet.

The Red Sea is the *Yam Suph* of the Mosaic narrative (Exod. xiii. 18), usually translated "The Sea of Rushes," or "The Weedy Sea," alluding to marine vegetation; but Rosenmuller has advanced cogent reasons for rendering it "The Sea of Madrepores," referring to the quantity of corals in its bed, and which appear on the banks at low water. The coral, according to Burckhardt, is red in the Gulf of Suez, and white in that of Akaba.

Rivers.—The Jordan drains the whole east of Palestine, from north to south. It is formed by a confluence of various streams in the north, the most remote of which, and the true geographical source, appears to be the river of Hasbeya, which takes its rise from a spring on the west slope of Jebel-esh-Sheikh (Hermon.) The river, when fully formed, has a wild powerful current, consequent on the great declivity of its channel, and a very erratic course, meandering 113 miles between the Lake of Tiberias and the Dead Sea, the direct distance being little more than sixty. The breadth and depth vary considerably at different points, and its general aspect changes remarkably with the season, being impassable in winter where it is fordable in summer. It receives an immense number of winter torrents, which completely fail in the dry months, only three or four being permanent, on the eastern side or left bank. Its course is entirely continental, lying through two lakes, and terminating in a third.

In early times, as now, the Jordan was crossed by ferry-boats, (2 Sam. xix. 18.) At different points the Arabs swim their horses over. But neither modes of passage are practicable in the rainy season.

Formerly the river seems to have periodically overflowed its banks, and inundated the surrounding country, (Josh. iii. 15.) It has not been ascertained whether this occurs at present, or a mere rise without an overflow. If any change has taken place, it must be owing to the stream having excavated for itself a deeper channel.

At its embouchere, the river, about 200 feet wide, is deep and rapid; but its current is immediately arrested by the denser waters of the Dead Sea.

FALL OF THE JORDAN, ACCORDING TO VON WILDENBRUCH.

	Length, Eng. Miles.	Height, Eng. Feet.	Fall per Mile, Feet.
At Tell el Kady Source (?)		+ 537·1	...
,, Bahr el Hulch, Entrance	9·0	+ 100·0	48·6
,, ,, Issue	4·0	...	...
,, Bridge of the Sons of Jacob	2·5	+ 89·9	4·0
,, Lake of Tiberias, Entrance	8·0	− 845·5	116·9
,, ,, Issue	14·0	...	...
,, The Dead Sea	80·0	−1446·3	7·5
Total Length and Fall	117·5	1983·4	...

PERPENDICULAR DISTRIBUTION OF ANIMAL AND VEGETABLE LIFE.

The Nahr-el-Kasimiyeh, ancient Leontes, drains the southern part of Cœle-Syria, rising in the neighbourhood of Baalbec, and entering the Mediterranean a few miles northward of ancient Tyre.

The Kison, "that ancient river, the river Kishon," (Jud. v. 21,) drains the Plain of Esdraëlon (Megiddo) in Galilee, rising to the south of the Gilboa ridge, and entering the Bay of Acre at the foot of Carmel.

The Nile traverses the whole of Egypt from south to north, diverging into two principal branches after passing Cairo, respectively called the Rosetta branch on the west, and the Damietta branch on the east, which enter the Mediterranean, and inclose between them the celebrated Delta, an area of nearly 2000 square miles,—an alluvial deposit of the river.

The annual inundations of the Nile, which render Egypt fertile, are caused by heavy periodic rains in its tropical districts. The rise commences about the time of the summer solstice, attains its greatest height at the autumnal equinox, remains stationary for some days, and gradually diminishes to the time of the winter solstice. According to Sir Gardiner Wilkinson, the lowest rise, allowing the least irrigation of the adjoining districts, is 18 cubits, of $21\frac{7}{8}$ inches each, when the canals are cut. A rise of 19 cubits is tolerable, 20 good, 21 sufficient, 22 fills every canal, and is termed perfect, while 24 would overwhelm everything. Hence a perpendicular rise of about 38 feet is necessary to complete irrigation.

Lakes.—Bahr-el-Huleh, "The Waters of Merom," (Josh. xi. 5,) the Samaco of the Jerusalem Talmud, and the Samochonitis of Josephus, one of the lakes of the Jordan in the north of Palestine, surrounded with low marshy shores, has no definite and permanent extent, the summer remarkably contracting its volume.

Lake of Tiberias, "Sea of Chinnereth," (Num. xxxiv. 11,) "Sea of Galilee," (John vi. 1,) "Lake of Gennesaret," (Luke v. 1,) another expansion of the Jordan, runs nearly north and south from twelve to fifteen miles, the breadth in general being from six to nine miles, mountains on every side distinctly marking its boundaries.

It may be described as longer and finer than any English lake, although inferior to Loch Lomond. It does not possess the vastness of the Lake of Geneva, although it much resembles it in certain points of view. In picturesque beauty it perhaps comes nearest to the Lake of Lugano in Italy, though quite destitute of anything similar to the islands by which that piece of water is adorned.—*Dr. E. D. Clarke.*

Bahr Lut, *Sea of Lot,* "Salt Sea" and "Sea of the Plain," (Deut. iii. 17,) Lake Asphaltites, Mare Mortuum, or Dead Sea, in the south of Palestine, the receptacle of the Jordan, extends about forty-five miles in length by ten in breadth. Its water has a far stronger saline impregnation than sea-water, containing one-fourth of its weight of solid matter, peculiarly bitter, pungent, and nauseous to the taste. According to the analysis of Dr. Marcet, 100 parts of it are composed of—muriate of magnesia, 10·246; muriate of soda, 10·360; muriate of lime, 3·920; sulphate of lime, 0·054; salts derived from the saline tracts in its neighbourhood, washed by the rains, and conveyed into the lake by the torrents. The depth in places exceeds 1,100 feet.

Cedars of Lebanon.

OUTLINES OF THE PERPENDICULAR DISTRIBUTION OF ANIMAL AND VEGETABLE LIFE, AS REPRESENTED IN THE ENGRAVED TITLE.

The Tableau prefixed to this work has been made at once to exhibit its object and its contents: indicating in striking characters our planet's surface and its organic life. Nor is it a mere vignette, originating in the artist's fancy,—but rather an instructive chart, laid down on a mathematically correct scale.

As organic life is infinitely varied between the Equator and the Poles, so is it in different stages of altitude; and in tropical countries when we ascend high mountains, we can transport ourselves in a few hours to polar-like regions. It must ever be the great aim with the chartographer of physical geography, to pourtray the results of dry figures and tables in a pleasing as well as distinct manner, and on this principle the present tableau has been constructed to embody and represent *graphically* the substance of all the important observations on the distribution of Organic Life in ascending regions. The different cones represent the various mountain-regions named at the bottom of the diagram. The height of these cones and the objects they exhibit are accurately laid down from the figures in the annexed Table, according to the scale engraved at both sides of the diagram. In thus estimating the height of the various mountain-tops, places, groups of plants, animals, glaciers, &c., they can easily be referred to in the Table; for instance, take the town immediately above St. Paul's in the group of the "British Isles;" and, in seeing it in line with about 500 ft., the Table will show that it is Birmingham.

The different cones are placed in juxta-position, in order that comparisons between tropical and northern countries may be readily drawn. Take our own islands and observe how their culminating points vanish before the colossal mountain-systems of other countries! Corn-fields are only seen below 1000 ft., and trees

PERPENDICULAR DISTRIBUTION OF ANIMAL AND VEGETABLE LIFE.

as far as about 2000, where in other cones rows of vines and palms are seen to grow in great profusion; but no eternal snows cover the summits of our mountains as in the Himalaya group, where people far above the snow limit are seen crossing the fearful passes, or as in the cone of Lapland (close at the left-hand), where glaciers run down to the level of the sea. How indicative these few features are of the temperate climate of the British Isles!

The next mountain groups behind those of our islands and Lapland, and the centre-piece of the whole tableau, represent the Alps,—a varied picture. From the sea-level upwards we see the vine, the large forest and fruit-trees, intermingled with extensive corn-fields; higher up, nearly in line with the top of Ben Nevis and the snow-clad Lapland mountains, we come to the true Alpine regions, where the birch and the pine-tree denote that degree of temperature which is especially suited to produce those beautiful mountain pastures resorted to by numerous herds of cattle and sheep, which are seen grazing in this region. At the same time those magnificent ice-rivers, the glaciers, intersect with irresistible force the cultivated regions; and, descending in some instances 5000 to 6000 feet in height from the place of their birth into the valleys, not seldom occupy ground formerly bearing corn. Those gloomy-looking houses near the snow limit, at about 8000 feet, represent the celebrated hospice of the Great St. Bernard, indicative of the near termination of animal and vegetable life; the three bridges over the glacier to the right-hand are the Simplon, St. Gothard, and the Stelvio Passes; a little carriage crossing the latter, reminds us of its being the highest carriage-road of Europe. In the snowy regions, the Col du Géant is also indicated, the highest of the European passes; above which are seen towering the Alpine giants, Mont Blanc, Monte Rosa, and the Ortler Spitze. Yet these European mountains are insignificant in comparison of those of the Asiatic and American continents; and nearly two Mont Blancs, one above the other, are required to equal the tops of the Himalaya system. In this, birch-trees, with tall stems, grow at a height of 14,000 feet; fields of barley 700 feet higher; and small bushes, which serve the inhabitants for fuel to warm their huts, in the latitude of 31° N., at a height of 16,945 feet.* Many of the passes are much higher than the top of Mont Blanc; that of Nako (on Purgeool), is 18,683 feet.

At both sides of the middle groups are represented the American mountain-masses, those of Quito, Peru, Bolivia, and Mexico. The various features and objects will readily be discerned by the aid of the Table.

The highest points ever attained by man are also indicated; Humboldt, on the Chimborazo, reached . . . . 19,286 ft.
Boussingault and Hall, on the same mountain . . . 19,695 „
Gerard, on Purgeool† . . . . . 19,411 „

The condor soars even higher: for one above the Antisana was computed to be fully 23,270 ft. high, by Humboldt, who believes that even this is not the limit of its power.‡

Yet man, the lord over the animal creation, surpasses the condor in its flight. Gay Lussac ascended, in a balloon, to a height of 23,000 ft., and Charles Green still higher, viz., 27,146 ft.; an altitude little short of that of the Dhawalagiri and Kunchinginga.§ (See letterpress, pp. 55, 56, and 71.)

* Humboldt, "Aspects of Nature," 1849, vol. i. p. 99.

† Gerard, Koonawur, Appendix.

‡ Humboldt, "Aspects of Nature," 1849, vol. i. p. 40. *et seq.*

§ Journal of the Meteorological Society of London, p. 64.

N.B.—All the figures in this Table denote English Feet, unless otherwise expressed. The figures with plants and animals give always their upper *limits, if no qualification is made.*

A. EUROPEAN GROUP.

I. BRITISH ISLES.(1)—LATITUDE, 50° to 59° N.

Mountains.—Ben Nevis (culminating point of Scotland and the British Isles) 4368
Snowdon (ditto of England and Wales) 3571
Carn Tual (ditto of Ireland) 3404

Places.—Carour (highest habitation of Great Britain). It is a hunting-lodge in the Central Grampians, on one of the wildest moors of Scotland, about 7 miles N.W. of Loch Rannoch, and corresponds in height with Bern and Munich 1740
Allenheads (highest habitation of England), in the S.W. corner of the county of Northumberland 1400
Birmingham (one of the most elevated of the larger towns of England) 500
St. Paul's, London, (height of building) 360

Plants.—Upper limit of forest-trees in the highlands of Scotland 2000
Ditto, cultivation of wheat, ditto 700
Ditto, ... oats, ditto 1000
(In Carour, 1740 feet, potatoes, beans, peas and cabbage, are still cultivated, though often not very successfully.)

Animals.—Highest point where sheep have been observed on Ben Nevis 3200
Upper limit of the common grouse 2500
Principal region of the ptarmigan ..... 2500 to 4000

Temperature.—Decrease of temperature on mountains (as observed by Forbes on the Pentland Hills),(2) 1° in 230 feet.
London, annual mean, 50°.1.
Decrease of the temperature of the air during the ascent in balloons (as found by Gay Lussac):
From 1 to 12,120 a decrease of 35° = 348 feet to 1°.
12,120 to 23,000 ... 42° = 257 ... 1°.
in 23,000 ft. ... 77°
Humboldt(3) gives for Central Europe (lat. 38° to 71°) 1° in 284 to 309 feet.

Height attained in balloons.—The greatest elevation ever attained was that by the well-known aëronaut, Mr. Charles Green, who, on the 10th of September, 1838, in his Nassau balloon, reached the height of 27,146 feet. Gay Lussac reached only 23,000.

II. LAPLAND.—LATITUDE, 67½° to 70° N.

Mountains and Passes.—Sulitelma (culminating point of the Kiölen Proper) 6177
Pass of Almajalos 5545

Plants.—Four Regions:
1. Forest Region:
   a, 0 to 530 (Pinus abies Trifol. pratense, Convall. majalis, and Nymphæa alba).
   b, 530 to 850, Region of the Pine (Pinus sylvestris).
   c, 850 to 1280, Region without pines. (Pinus sylvestris requires a temperature of not less than 30°.)
2. Subalpine Region, or that of the birch, 1280 to 1800. (Temperature not less than 27°.)
3. Lower Alpine Region, or that of the dwarf birch, 1800 to 2550.—(Salix lanata, Herbacea, &c.)
4. Upper Alpine or Snowy Region, 2550 to 4200.—(Rhododendron lapponicum, 3070.)

Heath as high as 2100; grain, 800; trees, 2000.

Temperature.—Snow limit, 3500.
Temperature at the snow limit, 21°.
Glaciers extend to the level of the sea.

III. THE ALPS.—LATITUDE, 46° N.

Mountains.—Mont Blanc (culminating point of the Alps and of Europe) 15,750
Monte Rosa 15,157
Ortler Spitze 12,850

Passes.—Col du Géant (highest pass in Europe) 11,274
Stilfser Joch, or Stelvio Pass (highest carriage-road in Europe) 8,850
St. Gothard (hospice) 7,087
Simplon 6,595

Places, &c.—Inspector's house at the Pass of Santa Maria (highest permanent habitation of Europe) 9,272
Hospice of Great St. Bernhard 8,185
Soglio (highest village of Europe) 6,714
Briançon (town) 4,285
Chamouny 3,454
Lake of Geneva 1,229

Plants.—Northern Slope:
1. Region of the Plains, 830 to 1020. Characterised principally by the cultivation of the vine. (The vine rarely grows as high as 1790.)
2. Lower Mountain Region, 1020 to 2700. Principal region of the oak; characterised by the ripening of the walnut, which sometimes ascends to 3000, as in the Valley of Hasli.
3. Upper Mountain Region, 2700 to 4200. Beech, the prevalent forest-tree. About the middle of this region (3500) is the upper limit of the fruit-trees: as, the cherry-tree, pear, apple; at the same height, the oak, elm, lime-tree, hazel, Ulmus campestris in the valley of Lauterbrunnen, 4350. The birch, a rare tree in the Swiss Alps, at least 5600. Acer platanoides, not above 4200. Quercus robur, in the Sextenvalley, 3580. Grain, 3650; potatoes, 4000.
4. Subalpine Region, 4200 to 5900. This is the region of the pine-trees; generally no other trees occurring. With this region the mountain-pastures begin, as also the châlets or huts, to which the herdsmen (whose employment it is to milk the cows and to make the cheese and butter) repair in summer. Principal forest-tree, Pinus picea du Roi; also, P. abies du Roi, P. sylvestris, P. larix and P. Cembra. (Pinus larix [larch,] sometimes 6400; P. Cembra, 6500.)
5. Lower Alpine Region, 5900 to 7400. Region of the shrubs: Rhododendron ferrugineum, Rh. hirsutum; also, Alnus viridis. This is the main region of the Alpine pasturage.
6. Upper Alpine Region, 7400 to 8800. Region of the low Alpine plants.

Southern Slope (Monte Rosa): Grain, 5000; trees, 6700; vine, 2200. (According to Gatta, vineyards in the valley of Aosta are occasionally found as high as 3940, probably the highest vineyards of Europe.)

Animals. — Mammalia: Bat, 7030; hedgehog, 8250; mole, 4500; brown and black bear, 8250; badger, 6400; weasel, 5500; stoat or ermine, 9600; otter, 8250; wolf, fox, wild cat, and lynx, 8250; chamois, between 6000 and 9000; cattle, 8000; sheep even higher; stag, 7000; fallow deer, 6000.
Reptiles: Common frog in the vicinity of the snow limit (8000); vipers, 5800; mountain lizard (Lacerta montana), 4500; Anguis fragilis, 6000.

Temperature.—Basle (805 feet) mean annual ..... 49°.3
Bern (2968) ditto ..... 46°.0
St. Bernhard (8175) ditto ..... 30°.1
Geneva (1335) ditto ..... 52°.7
St. Gothard (7087) ditto ..... 39° 1
Snow Limit: Northern slope 8800
Southern slope 9500
Glaciers: Lower Glacier of the Aar descends to 5900
Rosenlaui 5100
Upper Grindelwald Glacier 4300

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(1) The limits of animals and plants in this group are mostly from personal observation.—The chief authorities for the *Botanical* data of the Table are: Humboldt, Buch, Schouw, Wahlenberg, Decandolle, Meyen, Royle, Herbert, Gerard, Wallich, Hügel, Webb, Ramond, Unger, and numerous others. *Berghaus's Länder und Völkerkunde*, containing the most complete account of general physical geography ever published, treats also very completely on the Perpendicular Distribution of Plants,—an important subject, but scantily touched upon even in our latest and most popular works on Physical Geography.—*Meteorological* data from: Dove, Humboldt, (for limits of snow, see his "Central Asia,") Forbes, &c.

(2) Transactions Edin. Royal Society, vol. xiv, 1840.

(3) Kosmos, German edition, i, p. 354.

PERPENDICULAR DISTRIBUTION OF ANIMAL AND VEGETABLE LIFE.

Lower Grindelwald Glacier	3400
Source of the Arveiron, at the base of the Glacier des Bois (Valley of Chamouny)	3450

[All these glaciers are situated on the northern slope of the Alps.]

Decrease of Temperature on the—
Col du Géant (lat. 45° 51′ N.) 1° in 253 feet.
Righi (lat. 47° 1′ N.) 1° in 366 feet.

IV. ETNA.—Latitude, 37½° N.

Mountain.—Etna	10,882
Places.—La Maison Anglaise	9,537
Nicolosi (town)	2,175
Catania (town)	60

Plants.—1. Subtropical Region, 0 to 3500. Palm-tree, 1800; banana, Indian fig, Cactus optunia and maximus, 2340; cultivation of the vine is characteristic; apricots, almonds. Citus, 2000; olive-tree (cultivation of), 2340; orange, cotton, maize.

2. Woody Region, 3500 to 6500. The wood is not dense, but interrupted by lava streams and corn-fields. Oak prevalent; Quercus pubescens, 5860; cork-tree, maple, chestnut; Betula alba, 6500; cherries, 3200; pears, 3600; cultivation of rye, between 3500 and 5900.

3. Alpine Region, 6500 to the summit. Juniperus hemisph., 7600; Astragalus siculus, 8500 (this is the characteristic plant of the region); Senecio chrysanthemifolius, highest plant, to 9430. From hence utter barrenness prevails, and a black desert of fields of lava and ashes begins.

Temperature.—The only perpetual snow occurs in shaded crevices down to a height of 9500.

Etna (9201) mean annual	29°.6
Nicolosi (2175) ditto	60°.3
Catania (60) ditto	67°.4

B. AFRICAN GROUP.

V. TENERIFE, CANARY ISLANDS.

Latitude, 28° to 28½° N.

Mountains, &c.—Pic de Teyde	12,182
Monte de Chahorra	9,886
Laguna (town)	1,630

Plants.—1. Region of the African or subtropical forms, 0 to 1300. This is the region of the palms and baoanas; dragon-tree (Dracæna draco).

2. Region of the European or Mediterranean forms, 1300 to 2700. This is the region of the vine, comprising the most successfully-cultivated vineyards and cornfields.

3. Region of the Laurels, 2700 to 4350. Four species of laurel and a variety of evergreen trees, of the myrtle family, characterise this region.

4. Region of the Pines, 4350 to 6300. Pinus Canariensis.

5. Region of Retama blanca, a species of broom, 6300 to 11,100. Viola cheiranthifolia is the highest plant. Beyond this nothing presents itself but the naked pumice, obsidian, and lava of the cone of the volcano.

Temperature.—Annual mean in 8000 | 41°.0
Laguna (1630) mean annual | 62°.6
Santa Cruz (sea level) ditto | 71°.1

C. ASIATIC GROUP.

VI. HIMALAYA MOUNTAINS.

Latitude, 29° to 32° N.

Mountains.—Kunchinginga (highest known mountain of the world)	28,178
Dhawalsgiri	28,000
Purgeeol	22,488
Passes.—Pass of Nako, 32° 52′ N. lat., 78° 45′ E. long. (highest in the world!)	18,683
Pass Manerung	18,612
Places, &c.—Pamachun (village)	13,643
Reshee (ditto)	13,600
Shipke (ditto)	10,597
Gangotri (temple)	10,314
Ladak (town)	9,995
Darjeeling (ditto)	7,165
Kashmir (city)	5,818
Lake Manasarowar	15,250
Highest elevation reached by Gerard on Purgeeol (18th October, 1818. Temperature 11°, but no snow.)	19,411

Plants.—1. The Plains of Hindostan, 0 to 1300. In the jungles arborescent ferns and orchidaceous plants in profusion; palms, &c.

2. Lower Upland Region, 1300 to 5000. Mostly tropical plants.

3. Higher Upland Region, 5000 to 9000. The trees approach those of the Temperate Zone; region of the Rhododendrons. Principal fruit-trees: walnut, apricot, peach, pomegranate. This region is the most agreeable for the residence of Europeans (mean temperature about 55°). In the beautiful valley of Kashmir a temperate climate prevails, and European vegetation.

4. Alpine Region, 9000 to 13,000.

Limit of trees, &c., as observed by Gerard, in Koonawur.

Cheer pine	7,189
Mouroo oak	7,945
Ban oak (lowest limit, 5767)	8,010
Kyl pine (... 7006)	8,425
Green and black grape (at Soongnum)	9,500
Horse chestnut	10,353
Maple	10,906
Rhuharb and black currant	11,000
Gooseberries	11,366
Grain	11,500
Khursoo oak or holly (lowest limit, 9208)	11,782
Shoor juniper	11,842
Extensive beds of strawberries	12,000
Leem pine	12,140
Bhurglei-trees	13,060
Rye (near Dabling)	13,620
Gardens of apricots and fields of beans	14,000
Birch (lowest limit, 10,555)	14,006
Barley	14,707
Small bushes	16,945

Animals.—Mammalia: Wild ass (the kiang of Tibet, 15,300; semnopitheeus entellus (hoonuman), 13,000; tiger and leopard, 12,000; Cashmere goat, 13,000; argali, 13,000; Pamir sheep or rass, 15,600; Burrhel (Ovis Burrheli), 17,000; Yak or kash-gow (Bos grunniens), 18,000 (lower limit, 10,000?); Bactrian camel (in Central Asia), 5000; tailless rats (in great numbers), 13,000.

Birds: Robin redbreast (near the Boorendo Pass), 15,095; pigeons, 15,600; pheasants, 12,000.

Temperature.—Benares (300) mean annual	80°.3
Hawli Bagh (3888) ditto	59°.4
Darjeeling (7165) ditto	50°.7
Landour (7610) mean annual	55°.6
Springs of Jumnotree (10,849)	194°.0
(4)Snow Limit: Northern side	18,500
Southern side	15,500

D. AMERICAN GROUP.

VII. PERU—BOLIVIAN ANDES.

Latitude, 14° to 19° S.

Mountains.—Sahama	22,350
Sorata	21,286
Illimani	21,140
(Aconcagua, in Chili, 23,910.)	
Passes.—Rumihuasi	16,160
Altos de Toledo	15,700
Gualillas	14,750
La Raya	14,520
Places, &c.—Rumihuasi, post station	15,542
Potosi (city) highest city in the world	13,330
Titicaca (lake)	12,847

Plants.—Meyen describes the vegetation of the Peru-Bolivian Andes, thus:—On ascending from Arica you have to traverse for many miles a steppe of gravel and sand, a desert without any plants or animals. At Tacna (1840) some trees and bushes make their appearance; beyond this, olives, pomegranates, and figs are occasionally met with. You come next to the region of Cactus, 5000 to 7500. Higher up the vegetation is extremely beautiful; but at the pass of Gualillas (14,750) all vegetation has again ceased, and the whole broad mountain-crest is a desolate waste till you descend to the table-land of the Titicaca Lake. Few trees are met with on this table-land, which consists chiefly of extensive pastures and fields of grain. The road from Chuculito to Puno is like a flower-garden.

Maize, 12,900; wheat, barley, and other grain on the table-land.

Animals.—Cervus Andium, 11,000; vizcacha, 15,000; flamingo, 13,000; condor, its nest, 15,000, its flight, 23,300; hummingbirds, 14,600.

Temperature.—Snow Limit: Eastern chain, 15,900; western chain, 18,500.
Lowest glacier on Illimani, 16,500.(5)

VIII. ANDES OF QUITO.—Latitude, 0° to 10° N

Mountains.—Chimborazo	21,420
Antisana	19,137
Pichincha	15,922
Passes.—Pass of Assuay	15,528
Pass of Guanacas	14,708
Places.—Azufral de Juan (at the foot of Tolima)	13,512
Antisana, farm (pastures for cattle, mules, and horses)	13,451
Huancavelica (town)	11,734
Quito (ditto)	9,543
Caxamarca (ditto)	9,362
Bogota (ditto)	8,720
Pasto (ditto)	8,575
Almaguer (ditto)	7,437
Loxa (ditto)	6,778
Popayan (ditto)	5,825
Carthago (ditto)	3,152

Plants.—1. Tropical Region (*Tierra caliente*), 0 to 2000; temperature, 86° to 73°. It is the region of the palms and bananas (the latter occur sometimes as high as 3200.) Other characteristic plants are, ascending from the sea-level: Cocos nucifera, Mauritia flexuosa, Heliconia, Alpinia, Carica, Cæsalpinia, Guajacum, Swietania, Lecythis, Tibulus maximus, Theophrasta, Bertholletia excelsa, Bonplandia trifoliata, &c.; Schraukia hamata, Dismanthus lacustris, Coccoloba uvifera, &c.

2. Temperate Region (*Tierra templada*). 2000 to 7000; temperature, 73° to 63°. Principal plants: fern-trees and cinchoniæ (Cinchonia lancifolia and C. ovalifolia, sometimes 9000 and 10,700); fern-trees, generally between 2000 and 5000; peperomiæ, 5800.

These two first regions comprise the tropical cultivation plants; bananas, 3200; cacao (Cocos nucifera) chiefly in the sandy plains along the coast; coffee-tree chiefly between 1200 and 3000, sometimes to 7400. Sugar-cane reaches 3600; cotton, 4500; indigo not quite so high. In the region where all these preceding plants occur (3000 to 6500) maize is the principal plant of cultivation. European grains begin in the Andes at an elevation at which they end in the Alps.

3. Cold Region (*Tierra fria*), 7000 to 15,600; temperature, 63° to 35°:

a. Lower Cold Region (*Regio subfrigida*), 7000 to 10,000; temperature, 63° to 54°. Palm of Quindiu (Cenoxylon andicola), highest palm, 9270.

b. Region of the Paramos, 10,000 to 12,000; temperature, 54° to 42°. Dreary wilderness; in the lower part of which the last trees are met with,—in the upper part only bushes. Escallonia, Alstonia, 11,500; Erixinæ, Befariæ, 10,200.

c. Stony Region, 12,000 to 15,600; temperature, 42° to 35°. In this region there is no grain, scaicely any trees, and grass sparely.

Animals.—Mammalia: Mycetus rufimanus (beelzebul), 11,000; cattle, mules, horses, 14,000; bear, 16,000; Mephitis mapurito, 9000; jaguar, 3000; ocelot, 6000; puma, 12,000(?); llama, 15,800.

Birds: Condor, 23,300; Vultur aurea (Turkey buzzard), V. papa (king vulture), V. jota (black vulture), 16,000; green macaw, 3000; ibijau, 12,000 to 16,000; Cassicus, 7000 to 8000; Ampelis, 3000; Nandu, 6000 to 7000; Colymbus and Anas, 10,000.

Reptiles: Crocodiles and boas, 3000.

Temperature.—Snow limit from 15,400 to 15,800.

Highest point reached by Humboldt on Chimborazo, 23rd June, 1802	19,286
Ditto, by Boussingault and Hall, 16th Dec., 1831	19,695

IX. MEXICO.—Latitude, 17° to 21° N.

Mountains.—Popocatepetl	17,730
Jorullo	4,265
Places.—Toluca (town)	8,825
Las Alamas (village)	8,789
Mexico (town)	7,470
Guanaxuato (ditto)	6,836
Xalapa (ditto)	4,330

Plants.—1. Tropical Regions, 0 to 2000; temperature, 80°. Palms, &c.

2. Temperate Region, 2000 to 6000; temperature, 77° to 63°. Cultivation of grain; oaks, 3000 to 10,400.

3. Cold Region, 6000 to 15,000; temperature, 63° to 39°. Upper limit of trees, formed by Pinus occidentalis, 12,800; between it and snow-limit a difference of 2200.

Limits of Plants:] Sugar cane, cotton, indigo, cacao, to 2000 and 2700; wheat chiefly between 4500 and 10,000; Musa paradisiaca, one of the most beautiful of the tropical plants, ripens at 5000.

Temperature.—Mexico (7470) mean annual	60°.6
Vera Cruz (sea level) ditto	77°.0
Snow limit, 14,800.	

(4) Strachey, Journal of the Asiatic Society of Bengal, new Series, No. xxviii.

(5) Somerville's Physical Geography, new edition, i. p. 158.

ANNOTATIONS TO THE MAPS,

BY AUGUSTUS PETERMANN, F.R.G.S.

THAT which has especially promoted the progress of knowledge in the nineteenth century, and has formed the chief character of the age, is the general and highly useful endeavour, not to limit our regards to that which has just been achieved, but to test rigidly, by weight and measure, all earlier as well as more recent discoveries.

HUMBOLDT.

Diagram showing the
HEIGHT OF THE PRINCIPAL CULMINATING POINTS OF THE GLOBE.
Note. — The heights in figures of these culminating points are contained in the Map.

Explanation.

This Map is intended to represent the leading features of the surface of the Globe: its Mountains, Tablelands and Plains; their character whether Woodland, Prairies, Pampas, Llanos, Steppes, Deserts, Swamps, Lagoons &c.

The Mountains are carefully shaded to scale, the figures annexed to their names express the Height above the Level of the Sea in English feet.

As Temperature prominently operates on the Physiognomy of the Earth's surface, some Isothermal lines have been introduced, which form the boundaries of two characteristic Zones:

1. The Zone of Coral Reefs, *limited by the Isothermal lines of 70°F.*
2. The Zone of permanently frozen subsoil, *limited by the Isothermal lines of 30° Fahr.*

UNEQUAL DISTRIBUTION OF LAND AND W

In this sketch the Land has been shaded according to its relative elevation, the darkest tint denoting the highest Land.

London: Published by Orr and Comp

ICAL MAP
HE
B E,
g the
& PHYSIOGNOMY
URFACE
ted by
mann F.R.G.S.
d by
entonville.
ON.
No 1&2.
EASTERN HEMISPHERE
ARCTIC OCEAN
EUROPE
ASIA
AFRICA
SAHARA
INDIAN OCEAN
AUSTRALIA
ANTARCTIC OCEAN
Tropic of Cancer
EQUATOR
Tropic of Capricorn
Isotherme of 70°
Antarctic Circle
North Pole
South Pole
Explanation.
The names of the principal Mountain-Systems and Culminating points are engraved thus: The Alps. Mont Blanc
The names of Rivers, Seas and Places are engraved light, thus: R. Danube, Gulf of Mexico, Munich
Principal Abbreviations: Ch.- Chain, Ra.- Range, D.- Desert, O.- Oasis
The appellation of Mount, Mountains &c. is generally omitted.
Zone of Coral Reefs
Atolls or lagoon Islands
Barrier Reefs
Fringing Reefs
Zone of permanently frozen subsoil
Extent of Polar Ice
Regions of Depression (- signifies below the level of the Sea)
Woodland, Selvas
Savannas, Prairies, Pampas, Steppes
Swamps, Lagoons
Deserts
Diagram showing the
HEIGHT OF THE SNOW LINE IN DIFFERENT LATITUDES OF THE GLOBE
Note. —— Northern Hemisphere, ------ South. Hem. (For explanatn of colours see other diagram.)
Scale of Latitude
English Feet
Equator
Pole
owing
ATER ON THE SURFACE OF THE GLOBE.
& Amen Corner, Paternoster Row.

GEOLOGY.

I & II. MAP OF THE GLOBE (IN HEMISPHERES), SHOWING THE CONFIGURATION AND PHYSIOGNOMY OF ITS SURFACE.

WITH

ELEVATION OF CELEBRATED MOUNTAIN PASSES.
SKETCH, SHOWING THE UNEQUAL DISTRIBUTION OF LAND AND WATER ON THE SURFACE OF THE GLOBE.
DIAGRAM, SHOWING THE HEIGHT OF THE PRINCIPAL CULMINATING POINTS OF THE GLOBE.
DIAGRAM, SHOWING THE HEIGHT OF THE SNOW-LINE IN DIFFERENT LATITUDES.

In order to view the Mountain and River Systems of the Globe in their true proportions, a spherical projection has been chosen for this as well as for the Hydrographical Map, Nos. 4 and 5, as it exhibits the Earth's surface in a manner less distorted than Mercator's Charts, which are more suitable to represent Zones of Temperature, Winds, &c.

The Mountains, the main feature of the Map, have been drawn in the mode generally adopted, which is done by representing the two slopes of a mountain ridge, by shading. Straight black lines have recently been adopted in Physical Maps, but while this method—the most easy and inexpensive—is excellent in some respects, it presents at the same time serious defects; as, for example, it displays very indistinctly the table-lands of the globe, so important a feature in an Orographic Map. To show the great masses of elevated land strikingly, different tints of shading might, perhaps, be applied with advantage; such has been tried in the sketch at the bottom of the Map, "to illustrate the unequal distribution of land and water," &c., in which the darkest portions indicate the highest table-lands.

Of the other diagrams at the bottom of the Map, one shows the limit of perpetual snow in various latitudes of the globe; the length of the coloured lines indicates the height where permanent snow on certain mountains (named in the parentheses) begins. As these lines are arranged according to the scale at the bottom, which represents the latitudes from the equator (right hand) to the poles (left hand), a clear view can be obtained of the remarkable curve described; instead of its being highest under the equator, and gradually descending towards the poles, it rises between the parallels of 15° and 40°, and thence rapidly descends. The colours of the lines mark the different quarters of the globe in which the mountains are situated. (*See* letterpress, pp. 55 *et seq.*)

The figures, with the names of Mountains and Table-lands, express their height in feet. The following is a list of a few of the most important Mountains, with their respective heights; many are derived from recent hypsometric observations, some of which were not received sufficiently early to embody them in the letterpress.

	Feet.	
Kunchinjinga (*Himalaya Mountain*, culminating point of the world?) . .	28,178	(Journal As. Soc. of Bengal, Nov., 1848. This Mountain, so far as our present knowledge goes, may be regarded as the highest on the globe; Dhawalagiri being about a hundred feet lower, viz., 28,073 feet, according to Blake's measurements, which are preferred by Humboldt and Berghaus to those of Webb, who gives only 26,862 feet. A new determination of the Dhawalagiri however, it is said, leaves to the latter the first rank among all snow-capped mountains of the Himalaya. *See* Humboldt's "Aspects of Nature," Engl. edition, vol. i., pp. 92 *et seq.*)
Aconcagua (*Andes of Chili*, culminating point of the New World) . .	23,910	(23,000 feet was the height hitherto assigned to it. A re-calculation of the elements, however, makes it 710 feet higher. *See* Somerville's "Physical Geography," v. ii., p 425.)
Sahama (*Bolivian Andes*, culminating point)	22,350	(Pentland, "Map of the Laguna of Titicaca," &c., 1848. The Sorata was for a long time past considered to be nearly 4,000 feet higher, when Pentland corrected his former statement in the above map. Recent trigonometrical measurements of Mr. Pissis make the Illimani 21,355 feet. *See* "Comptes Rendus," t. xxix., 2 Juillet, 1849.)
Sorata or Ancohuma (*ditto*) . . .	21,286	
Illimani . . (*ditto*) . . .	21,149	
Kilimandjāro (*East Africa*, culminating point of Africa?) .	20,000 to 25,000?	(Rebmann, "Church Missionary Intelligencer," May and November, 1849. This mountain, on account of its being covered with eternal snow, in a latitude so near the equator, cannot be less in height than 20,000 feet.)
Elburz (*Caucasus*, culminating point) .	18,493	(Fuss, Sabler and Sawitsch; Humboldt's "Central Asia," v. i., p. 396.)
Mont Blanc (*Alps*, culminating point) .	15,750	(Eschmann, "Ergebnisse der Trigonometrischen Vermessungen der Schweiz," 1840. The mean of the various Swiss, Piedmontese, and French triangulations is 15,742 feet, which is given in the Map in round numbers of 15,750, as the height of snow-covered mountains can never be ascertained exactly to a foot; for the variations produced by the melting of the snow are so great, that in Switzerland they may amount to twenty feet in one year.)

GEOLOGY:—MAP I. & II.

Sierra Nevada (*California*) . .	15,000	(Fremont, "Map of the Oregon and Upper California," 1848; also, "Geographical Memoir" illustrating this Map.)
Shasti. . . (*ditto*) . . .	14,000	
Fremont's Peak . (*ditto*) . . .	13,570	
Demavend (*Persia*)	14,700?	(Thomson and Ainsworth, "Journal R. Geogr. Soc.," 1838, vol. viii., p. 112. In several works the height has been stated at 14,695, leading to the belief that it had been very minutely ascertained, while it results from only a very rough computation, and is altogether doubtful. Most probably the elevation is much greater than that hitherto assigned to it, as Humboldt, after a careful re-calculation, finds it 19,609 feet, which is nearly 5,000 feet higher! *See* Humboldt's "Central Asia," vol. ii., p. 203.)
Indrapura (*Sumatra*)	12,300	(Of this mountain, Junghuhn states that it is unquestionably the highest in Sumatra. He makes the Singallang only 9,635 feet, which therefore requires correction in the Map. *See* Junghuhn, "Die Battaländer auf Sumatra," 1847.)
Spitzkop (*South Africa*, culminating point)	10,250	(Sherwill, "Nautical Magazine," February, 1849, p. 78.)
Potrillo (*Cuba*)	9,000	(Maltebrun and Balbi, 1842; Mitchell's "School Atlas," 1847. Generally the Coldridge, in Jamaica, with 8,185 feet, has been regarded as the culminating point of the West India Islands; the authority of Maltebrun and Balbi, however, who state the altitude of Potrillo, as early as 1842, corroborated in a transatlantic work, leaves little doubt that the latter must be regarded as the highest of the West India Mountains. Its position is laid down in Woodbridge's "Modern Atlas," 1843, in about 80° W. long. Greenwich.)
Pedrotallagalla (*Ceylon*) . . .	8,326	(Fraser's "Trigonometrical Survey of the Kandian Districts of Ceylon," 1845.)
Adam's Peak (*ditto*)	7,379	
Kosciusko (*Australia*)	6,500	(Strzelecki, "New South Wales," &c., 1845. The height of the Australian Alps has been greatly overrated, it having been stated as high as 15,000 feet, while, according to Strzelecki's authority, the highest top is only 6,500. This is the culminating point of Australia, and 5,520 that of Tasmania.)
Humboldt (*Tasmania*)	5,520	
Black Mountains (*Alleghannies*) . .	6,476	(According to the most recent authorities, as "Haskel's Gazetteer," 1847, &c., the Black Mountain in North Carolina is higher than Mount Washington. The position of Black Mountain, according to "Tanner's Map," 1844, is 36° 00′ N. lat. and 82° 20′ W. long. Greenwich.)
Washington (*ditto*)	6,428	

As the foregoing heights are the culminating points of the most important Mountain-systems of the Globe, the authorities have been stated somewhat circumstantially. For other details the reader must be referred to the Map itself, in which they have all undergone the same scrupulous analysis.

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GEOLOGY.

III. MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF ACTIVE VOLCANOES AND THE REGIONS VISITED BY EARTHQUAKES.

WITH

SKETCH OF THE GLOBE, SHOWING THE DIVISIONS OF ALL VOLCANOES INTO FOUR SYSTEMS.
DIAGRAM, SHOWING THE ELEVATION OF SOME OF THE PRINCIPAL VOLCANOES.
SKETCH OF THE EXTENT AND INTENSITY OF THE EARTHQUAKE ON THE RHINE, JULY 29TH, 1846.

THE beholder of this Map will at once be struck by this remarkable feature in the distribution of active volcanoes, that they are all, with few exceptions, confined to the littoral portions of the continents, or the islands, so that by far the greater area of the earth's surface is free from them: the blank spaces of the Map show that the eastern parts of the New World, the northern parts of Europe and Asia, and almost the entire Continents of Africa and Australia, contain no active volcanoes, and earthquakes are rare, and slight in their effects. The Pacific Ocean, with the coasts and islands which surround it, forms the principal seat of volcanic action, and a complete girdle may be traced around that ocean, from the southern extremity of America northward along its western coasts, the eastern coasts of Asia, and the islands that environ Australia; it is even prolonged to near the south pole by the volcano of the Balleny Islands and the mighty Erebus. To view this immense circle in connection, the Map has been constructed so as to have the Pacific Ocean in the centre.

As the position of the active volcanoes is so intimately related to the sea, the whole system has been divided into three groups, according to the great oceans, and a fourth one, that of Central Asia, comprising the Peshan, Hotcheou, and Demavend. These four groups are represented in the small hemispheres at the bottom of the Map, in which the system of the Pacific Ocean will appear still more striking. The amount of active volcanoes comprised in the latter is about two hundred, or more than two-thirds of the entire number.

The Sunda Isles comprise, on a comparatively small area, a very great number of volcanoes, Java alone containing forty-three, active and extinct. In Sumatra, hitherto only six active volcanoes were known; Junghuhn,* however, to whose explorations we owe so much for the knowledge of that island, has discovered ten more: the entire number, according to his authority, are enumerated in the following list, proceeding from N.W. to S.E:

Volcanoes.	Lat.	Long. Gr.	Height.
	° ′ ″	° ′ ″	Feet.
Mount Elephant, or Friar's Hood (doubtful)	5 07 0 N.	96 58 0 E.	—
Batu Gapit	3 42 0 "	98 10 0 "	—
Dolok Dsaut	1 55 0 "	99 15 0 "	—
Lubu Radja	1 24 50 "	99 13 50 "	6,235
Seret Berapi	0 43 0 "	99 38 50 "	—
Gounong* Ophir, or Passaman	0 5 0 "	99 58 0 "	9,603
G. Merapi	0 17 0 S.	100 36 30 "	9,571
G. Singallang	0 18 0 "	100 27 50 "	9,635
G. Talang	0 57 0 "	100 50 0 "	7,500
Indrapura (identical with G. Api?)	1 45 0 "	101 35 0 "	12,300
V. of Bencoolen	3 20 0 "	102 20 0 "	10,000
Volcano to the south-east of the preceding	3 38 0 "	102 30 0 "?	—
G. Dempo	3 54 0 "	103 35 0 "	11,000
G. Panjong, or Pujong	5 0 0 "	103 38 0 "	7,000
Kaiserspik, (*i. e.* Emperor's Peak)	5 18 0 "	104 30 0 "	6,500
V. of Isle of Tuboan	5 50 0 "	104 45 0 "	—

* "Gounong" means mountain, or summit.

Besides these sixteen there is a seventeenth, between Indrapura and V. of Bencoolen, whose position is uncertain. There is also, according to Dampier in the northern parts a volcanic mountain, called Golden Mountain.

There are at present known, in all, 290 active volcanoes.

* Franz Junghuhn, "Die Battaländer auf Sumatra," 1847.

GEOLOGY:—MAP III.

The earthquake districts are indicated by shading. Central Europe, happily, is nearly exempted from the awful visitation of severe earthquakes; the diagram at the bottom of the Map represents graphically the terrible and extensive one which occurred in Germany in 1846, being at the same time confined to Central Europe. It ranged from Hanover in the north to near Switzerland in the south, from Belgium in the west to beyond Würzburg in the east, and had its focus on the Rhine. It appears that this remarkable earthquake was preceded by various meteorological phenomena, particularly continued droughts and a tropical heat, reaching in June to 95° in the shade. In the previous winter and spring, the activity of the subterranean volcanic influence had shown itself by repeated earthquakes on the coasts of the Mediterranean; the island of Graham, or Hotham, near Sicily, having suddenly risen from its waters in 1831, but afterwards sunk, first about seven feet beneath the waves, and ultimately to the depth of thirty-two fathoms. In Iceland, the great eruption of September, 1845, was renewed in March, 1846, with such violence that the height of the flames emitted through the three craters of Mount Hecla is said to have amounted to upwards of 15,000 feet. Such was the state of volcanic activity round Europe previous to July, 1846; when, in this month, symptoms of slight earthquakes were observed in several places in Germany. But it was on the evening of the 29th July, at half-past nine o'clock, when suddenly in this large district (shown on the Map) a wave-like convulsion of the earth was felt, and three distinct shocks, of which the second was the strongest, were sustained in a great number of places. The time of duration was from five to six, and even twenty seconds; in some places one and two minutes were noted. Two works,* which present the history of this earthquake, contain many interesting details. In the districts of Frankfort and Kreuznach, the noise of the first shock resembled the rattling of heavy waggons or the roll of distant thunder, bells were set a ringing, persons and furniture were overthrown; birds were seen flying about in great confusion, horses and cattle showed great alarm by snorting and bellowing. Many people left their houses and encamped in the open air during the night. In Bockenheim, near Frankfort, a man writing at his desk was suddenly raised in his chair and moved from one side to the other; in other places children were thrown out of bed; while near Caub, even rocks were dislodged. In the atmosphere of the countries affected by this visitation, there existed for some time previously a perfect calm.

The degree of intensity is shown on the Map by three different tints of shading.

* Boegner, das Erdbeben und seine Erscheinungen. Nebst einer chronologischen Übersicht der Erderschütterungen im mittlern Deutchland, vom 8 Jahrhundert bis auf die neueste Zeit, 1847.

Nöggerath, das Erdbeben vom 29 Juli, 1846, im Rheingebiet und den benachbarten Ländern, 1847.


HYDROGRAPH
OF THE
WOR
Chiefly with re
to the
DIVISION OF T
AND THE BOU
OF THE
RIVER SYS
Constructed
Augustus Peterman
Engraved by
I. Dower . Penton
London.
WESTERN HEMISPHERE
North Pole
ARCTIC OCEAN
NORTH PACIFIC
PACIFIC OCEAN
NORTH ATLAN
ATLANTIC
OCEAN
Tropic of Cancer
EQUATOR
SOUTH PACIFIC OCEAN
Tropic of Capricorn
ATLANTIC
Discovered 1513 by Vasco Nuñez de Balboa, from the Isthmus of Panama, navigated and named by Magalhaen 1520
Antarctic Circle
ANTARCTIC OCEAN
(Extent of Land unknown)
Highest Latitude reached in the Antarct Oc. (78° 10') Ross 1842
South Pole
Elevation of some of the
Above Level of the Sea
SKETCH showing the COMPARATIV
Remark on the Division

OLD WORLD (contin^d^)

River	Engl. Miles
Gariep	?1000
Murray	?1000
Dvina	1000
Indigirka	1050
Meinam	1080
Si Kiang	1110
Don	1110
NEW WORLD	
Magdalena	1050
Orinoco	1560
Columbia	?1570
S. Francisco	1610
Saskatchawan	1920
St. Lawrence	2070
R. del Norte	?2120
La Plata	2210
Mackenzie	2440
Amazons	3550
Mississippi (Source of Missouri)	4100

DIAGRAM showing the COMPARATIVE LENGTH →
(on Scale of Map)

Explanation.

The Colours *indicate the extent of the different Oceans and the Waterparting or natural Boundaries of the River Systems, belonging to each.*

The shaded Districts, ▭, *comprise the Regions drained off by Rivers, which do not immediately reach the Sea, but discharge themselves into Lakes or are lost in the Sands, etc.*

All River Basins, *comprising an area of* 300,000 Engl. Square Miles *and upwards, are defined by coloured Lines, and inscribed with the name of the River* (Danube) *and its area in E. Sq. Ms.* (311,000). – *(The area of the following Rivers: Amazons, La Plata, Nile, Niger, St. Lawrence, Ganges, Tocantins, Orinoco, Gariep, Murray, – is carefully calculated from the most recent Maps, that of the rest is based on the authority of Berghaus and the Encyclop. Britannica)*

*London, Published by Orr and Comp^y^*

ICAL MAP
E
LD,
egard
HE OCEAN
NDARIES
F
STEMS.
by
n, F.R.G.S.

E EXTENT of the OCEANS

of the Ocean

cludes in the North Iceland, all Greenland, Hudson Strait, part of Hudson Bay …
outh: S. Shetland, Graham Land and the Line of Pack Ice, whereas the Polar Circles exclu…
of these parts. — 2. An extension of the Polar Seas to the 60° Lat. would be justifi…
ccount of the very unequal Division of the Ocean and the smallness of the Polar Seas as
tic & Indian Ocean.

lmen Corner Paternoster Row.

Explanation

The Names of Rivers & Lakes are engraved bold: **Nile**, **ARAL S.** **Chad**. *Tzána*
" " " *Oceans* " " " *open:* OCEAN
" " " *Parts of the Ocean* " *light:* Sea Gulf, *Strait*
The Lakes are classified according to size:
LAKES *with an area of 20 000 Engl. Square Miles and upwards*
Lakes " " " " *5 000 to 20.000* "
Lakes " " *under 5 000* "
The appellation of River *and* Lake *is throughout omitted.*
Abbreviations: S. = Sea | B. = Bay | Ch. = Channel | N. = North
St. = Strait | G. = Gulf | Cr. = Creek | S. = South
Doubtful Waterparting is marked by a broken line thus - - - - - - - - - - -

OLD WORLD

River	Engl. Miles
Senegal	1140
Olenek	1150
Dniepr	1240
Tarim	1240
Syr Deria	? 1390
Amu	1610
Euphrates	1720
Danube	1725
Ganges	1940
Brahmapoutra	? 2000
Indus	? 2260
Houng Ho	2300
Volga	2350
Obe	2670
Amour	2740
Lena	2770
Bahr el Azrek	2830
Niger	? 3000
Yenisei	3230
Yang-tseu Ki-ang	3320

Bahr el Abiad (true Nile) computed to be 3600 miles long

← of the PRINCIPAL RIVERS of the GLOBE
(on Scale of Map)

HYDROGRAPHY.

IV. & V. MAP OF THE WORLD (IN HEMISPHERES), CHIEFLY WITH REGARD TO THE DIVISION OF THE OCEAN, AND THE BOUNDARIES OF THE RIVER SYSTEMS.

WITH

ELEVATION OF SOME OF THE PRINCIPAL LAKES.
SKETCH, SHOWING THE COMPARATIVE EXTENT OF THE OCEANS.
DIAGRAM, SHOWING THE COMPARATIVE LENGTH OF THE PRINCIPAL RIVERS OF THE GLOBE.

On this sheet the earth's surface is represented in its great natural divisions, which are established by the distribution of its waters—the Oceans and the Rivers. The former are generally divided into five parts; which are thus enumerated according to their respective size:

1. Pacific, or Great Ocean;
2. Atlantic Ocean;
3. Indian Ocean;
4. Antarctic Ocean;
5. Arctic Ocean.

The boundaries of these oceans are mostly determined by the land, sometimes by imaginary lines, as is especially the case with the Antarctic Ocean. The forms of the ocean, that is to say, its indentations into the continent, such as gulfs and bays, are of important bearing on the condition of mankind, the sea having been in all ages the great connecting link in their intercourse. Deeply indented countries have always been the centres of civilisation; those surrounding the Mediterranean Sea may be instanced as offering a striking example. Of all the oceans of our globe the North Atlantic forms comparatively the greatest number of indentations, and in this respect Europe and North America, the two countries bounding it on the east and west, are favoured before all other continents of the globe, in being thrown open from so many points to commercial intercourse. It is quite different, with the Pacific Ocean: its eastern boundaries consist mostly of rounded lines, and so, too, the southern part of the western ones, while the indentations in the northern portions must be allowed to have influenced the high civilisation of the Chinese and Japanese.

The oceans are continually fed by the rivers which drain the continents, and the districts of each is distinguished in the Map by different colours, according to the five oceans. The Atlantic receives its supply from the greatest rivers of the globe, and drains the greatest area of its surface. Enumerating the oceans according to the number and size of the rivers that flow into them, they follow thus:

	Basin of the River.	Area in English Square Miles.		Basin of the River.	Area in English Square Miles.
Atlantic Ocean	*Amazons	2,275,000	Arctic Ocean	Obe	1,250,000
	*Nile	1,425,000?		Yenisei	1,040,000
	Mississippi	1,333,000		Lena	800,000
	*La Plata	1,242,000		Mackenzie	590,000
	*Niger	800,000?	Pacific Ocean	Amour	800,000
	*St. Lawrence	526,000		Yang-tseu-Kiang	750,000
	Saskatchawan	478,000		Hoang-ho	710,000
	*Tocantins	381,000	Indian Ocean	*Murray	480,000?
	*Orinoco	360,500		*Ganges	416,000
	*Gariep	360,000		Indus	410,000
	Danube	311,000	Antarctic Ocean	Receives no rivers.	

The areas of Rivers with an asterisk are derived from original calculations.

The foregoing list contains all river-basins with an area of 300,000 square miles, and upwards, (except that of the Volga,) numbering in all twenty-one, of which the smallest, the Danube, drains a district as large as France and the United Kingdom together, and the largest, that of the river Amazons, nineteen times more extensive than the latter. The basins of these rivers are delineated in the Map, and their area inscribed in each.

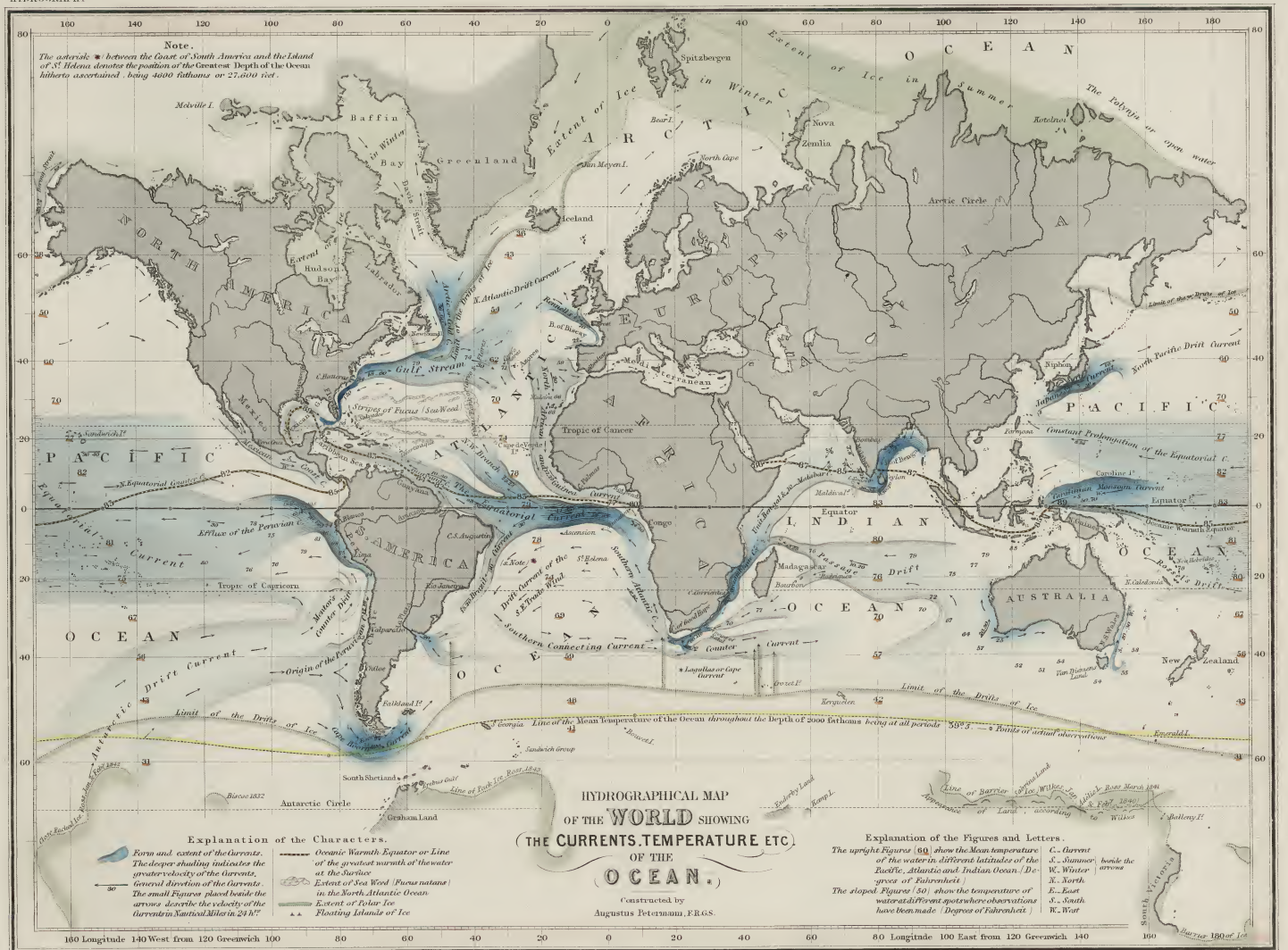
When we compare, on inspection of the Map, the drainage of the two principal oceans, the Pacific and the Atlantic respectively, we cannot but be struck with the immense quantity of water that must be received by the Atlantic in comparison to the Pacific; most of the great store-houses of rivers, the snow-beds of the Andes, Rocky Mountains, Alps, and, doubtless, those of the Mountains of the Moon, continually send forth their large supplies to the Atlantic basin.

HYDROGRAPHY:—MAP IV. & V.

Does this produce a difference in their levels? and is the Atlantic Ocean higher than the Pacific? are questions which arise naturally enough. It is a well known fact that in some smaller and more confined portions of the ocean such a difference exists; for example, the Black Sea: this detached basin receives the supply of a much greater number of rivers comparatively than the Mediterranean, and is so much higher than the latter, that a powerful current is known to flow from it through the Bosphorus, the Sea of Marmora, and the Dardanelles. In the Bosphorus this current is compressed between narrow and steep coasts, resembling an immense river, whose velocity is equal to that of the Rhine at Coblentz, and in one place, called "Devil's Current," it exhibits even double the velocity, viz., 25 to 30 miles in an hour. The difference in the levels of the Black Sea and the Mediterranean has not been ascertained, but judging from the degree of velocity and the distance from the Bosphorus to the Dardanelles, which is about 170 miles, it may be conjectured as 50 feet. The Adriatic Sea likewise is said* to be several feet higher than the Mediterranean at Marseilles; but the exact height has not yet been satisfactorily determined. In the New World, the Mexican Gulf reminds us of the Black Sea, for it has a similar confined and detached configuration, and receives also the waters of immense river basins; the waters thus collected, and further augmented by a slight current coming from the Caribbean Sea, seek an outlet into the open ocean; this outlet is the Strait of Florida, which from its narrowness, compresses the great mass of waters into the celebrated Gulf Stream, extending to the European shores. From the distance it has to traverse as far as the Azores, viz., about 3000 geographical miles, a considerable height of the Mexican Gulf above the Atlantic at the Azores must be inferred. The difference of the oceans at both sides of the northern part of the Florida peninsula has been ascertained by Poussin to be four feet; the points of observation, however, are not within the reach of the currents, and relate to the mouths of the Suwanee and St. John's Rivers. Though the instances here adduced seem to favour the supposition that the levels of the different oceans would be affected by the comparative supply of water from the land, it must entirely fall to the ground by the fact, that, contrary to anticipation, the level of the Pacific is even higher than that of the Atlantic. Humboldt believes, according to results of barometric observations, that the Atlantic at Cumana, Carthagena, and Vera Cruz, is about ten feet higher than the Pacific at Acapulco and Callao. According to several surveys made of the Isthmus of Panama, Lloyd, in 1818, found the mean level of the Pacific 3·52 feet higher than that of the Atlantic Ocean at Charges; but the result of Napoleon Garella's survey,† in 1845, makes the difference 9·54 feet.

* Humboldt, "Central Asia," German edition, i., p. 551, *seq.*

† Rockwell, "Report on Railroad and Canal Routes between the Atlantic and Pacific Oceans," 1849.



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Engraved by J. Dower, Beaufortville

HYDROGRAPHY.

VI. MAP OF THE WORLD, SHOWING THE CURRENTS, TEMPERATURE, ETC., OF THE OCEAN.

While in the preceding Map we have viewed the rivers of the land, in this we have before us the great streams of the ocean.

Currents.—It is the principal aim of this series of Maps to give general views of the entire surface of the globe, for from such only can the great laws of physical phenomena be readily apparent. Cast a glance at this Map, on which the ocean currents are prominently marked with blue colours; there is a diversity of shape, extent, direction, and force between them, almost as great as between the rivers; still, take the tropical zone, which embraces the greater number of the most important currents, and it will be perceived that their general movement is the same in the Atlantic, Pacific, and Indian Oceans; arising from the combined action of the rotation of the earth and the trade winds, which makes them flow from east to west. Follow their course, and observe the effect of their approach to land—the passage-drift of the Indian Ocean towards Madagascar—the equatorial current of the Atlantic towards the American promontory, and others;—how, by the resistance they encounter, they are split into different branches—how, by the formation and arrangement of the continental coasts, they are modified in shape, extent, and force. In these two influences, the rotation of the earth and prevailing direction of the winds on one hand, and the formation of the coasts on the other, lies chiefly the secret of the geographical distribution of the ocean currents. It is to the peculiarly-shaped basin of the Mexican Gulf, and of North America generally, that Europe principally owes its mild climate. The equatorial current flowing into the Gulf from the south, unites with the great masses of water supplied by the Mississippi, &c.; these rush on to find their outlet into the open ocean. This outlet, the Florida Strait, being very narrow, produces the powerful Gulf-stream, which again receives a north-easterly direction towards the European continent from the coasts of North America. At the same time, the waters of this current being heated in the so-called Mexican "Cauldron," heighten considerably the temperature of all those regions to which they extend.

The effects and influences of the currents are very various and important (*See* letter-press, p. 69). Indeed our knowledge in this respect becomes daily augmented, as Physical Geography begins to be more generally studied and investigated; and not the least interesting and important of recent facts is, that the *districts of the whale fishery* are in close connection with, and dependent on the currents. The favourite and appropriate food of the sperm whale is a gelatinous medusa, which, from its principal habitat, the polar regions, is borne off by the polar currents, towards the equatorial regions, when the whales are caused to follow. From an examination of the particular localities in which they are found most numerous, Wilkes* is induced to believe that these places of resort strikingly correspond with the neutral points, or spaces of no current.

Temperature.—All figures in the Map, except those beside the arrows, denote the temperature of the surface of the water; those underlined with orange colour express the mean annual temperature of the three oceans, from 10° to 10° of latitude. The Atlantic Ocean exhibits a considerably increased temperature in its higher latitudes, but a diminished one in its equatorial regions, in comparison with the other oceans. The following Table gives the different figures and their decimals, which were omitted in the Map for the sake of simplicity:

Latitude.	Atlantic Ocean.	Indian Ocean.	Pacific Ocean.	Latitude.	Atlantic Ocean.	Indian Ocean.	Pacific Ocean.
deg.	deg.	deg.	deg.	deg.	deg.	deg.	deg.
60 N.	42·8	—	38·3	60 S.	—	—	31·5
50 "	54·0	—	49·6	50 "	48·0	41·9	43·2
40 "	62·2	—	59·5	40 "	58·6	56·5	56·3
30 "	69·8	—	70·0	30 "	69·3	69·8	66·7
20 "	74·3	—	76·8	20 "	73·6	76·1	75·2
10 "	78·2	86·0	81·7	10 "	77·7	79·7	80·8
0 Equator.	79·0	83·3	83·1	0 Equator.	79·0	83·3	83·1

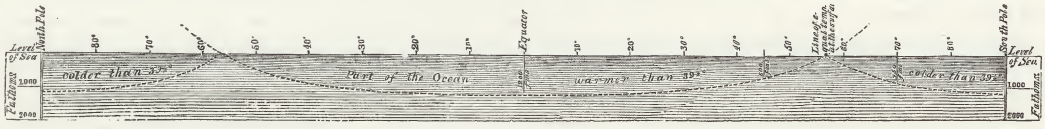
An inspection of the Map will show that the line of the greatest warmth of the oceanic waters does not coincide with the terrestrial Equator, but

* U. S. Exploring Expedition, 1845.

lies mostly north of it in one place, viz., in the Mexican Gulf as much as 28°, or nearly 2000 miles. The absolute greatest temperature (mean) amounts to 89°, and occurs in the Mexican Gulf and near New Guinea.*

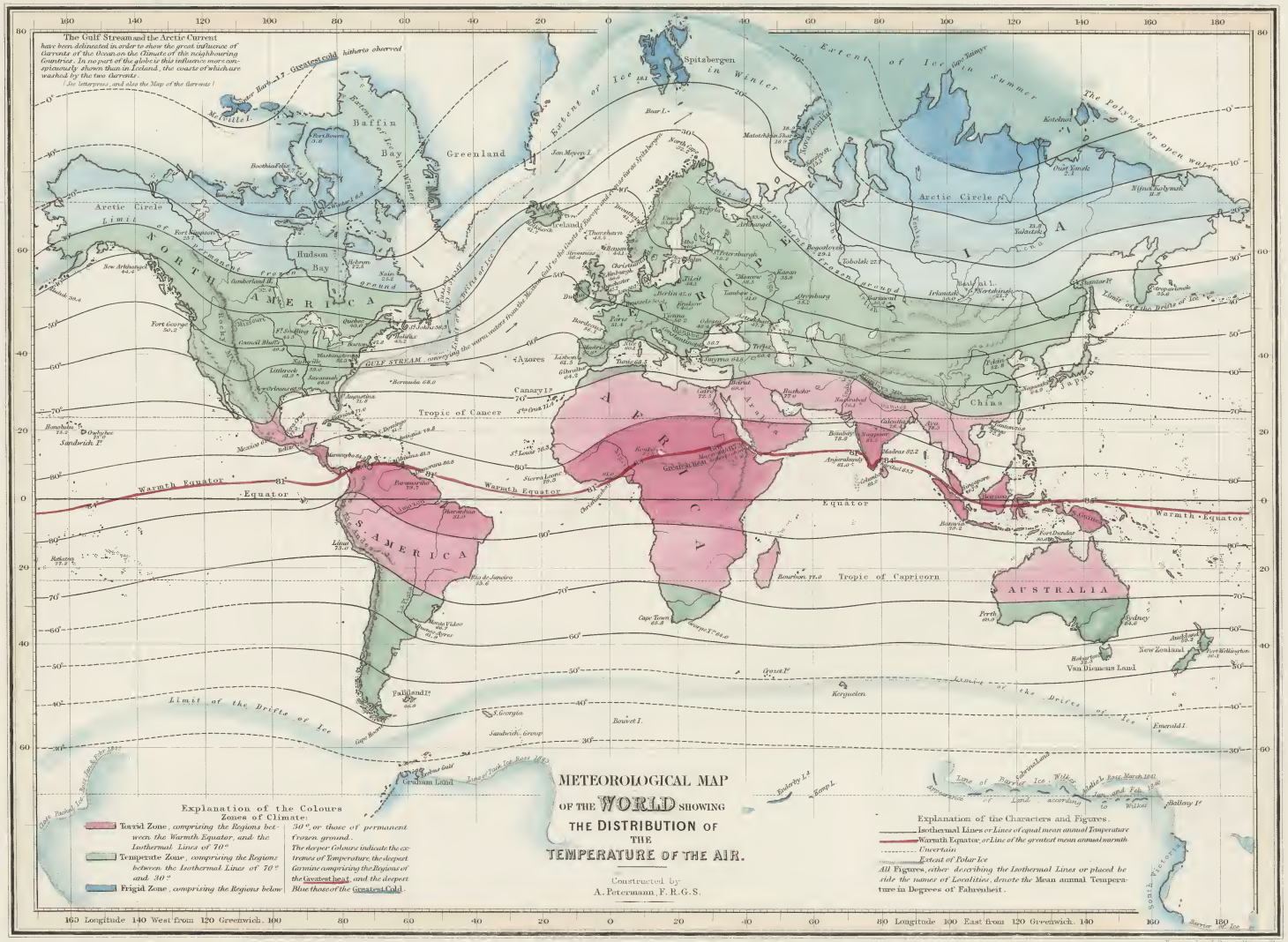
The faint red line south of Cape Horn, indicates one of the most interesting and beautiful results in Meteorology obtained by the Antarctic Expedition under Captain Ross.† It was found, by numerous observations of the temperature of the ocean, that the sun's rays influence its temperature only to a certain depth, viz., to about 1200 fathoms in the equatorial regions, and 600 fathoms in lat. 45° S.; below these depths the ocean has an unvarying mean temperature of $39\frac{1}{2}$ degrees. In the latitude of $56\frac{1}{4}$° S., the surface of the ocean water exhibits this mean of $39\frac{1}{2}$ degrees, and it follows that the sun does not affect the temperature of the ocean at all; and even south of this latitude a greater absence of the sun's heat occasions the sea to be colder. Hence, there exist, two great thermic basins in the upper portion of the ocean, one warmer than the standard heat of $39\frac{1}{2}$ degrees, the other colder; and the boundary between these two basins is that delineated in the Map, which consequently forms the standard line of oceanic temperature. The conjectural curve has been described in the following diagram from Ross's data.

DIAGRAM REPRESENTING THE OCEAN FROM THE NORTH POLE TO THE SOUTH POLE, TO SHOW THE LINE OF EQUAL TEMPERATURE AT A CERTAIN DEPTH.



* In the valuable "Narrative of the U. S. Exploring Expedition," a Chart of the World is given, showing the temperature of the ocean in lines from 5° to 5°; but while this map has the appearance of great care and minuteness, it is very much to be regretted that the explanations given to it are insufficient to make it understood. No figures in the chart show what temperature the lines indicate; but to conclude from vol. v. p. 458, where it is said that they range from 30 to 95 degrees, a large space in the Pacific, about the size of Australia, exhibits a temperature of 90°; and round the islands called "Union Group," between Phœnix and Samoa Group (9° S. lat., 172° W. long.), even 95° and upwards. With this, however, the text disagrees considerably when, in vol. v., p. 475, it is remarked, "In passing the Phœnix Group, a space in the ocean was traversed, remarkable for its elevated temperature, which was as high as 89°."

† Ross's Voyage to the Southern Seas, 1839 to 1843.



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METEOROLOGY.

VII. MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF THE TEMPERATURE OF THE AIR.

The distribution of temperature over the globe is shown by means of isothermal lines, or curves, which are drawn through places with the same mean temperature—generally the mean of the whole year. On this Map such lines are constructed at intervals of ten degrees. If we take the isothermal of 50°, a temperature very nearly that of London, and go along this line round the globe, we find that Vienna, the Crimea, Astrakhan (its south border), and Pekin, in the Old World; the mouth of the river Oregon, New York, and the southern extremity of the Canadian lakes in the New: correspond in their mean annual temperature with London, although they considerably vary in their respective latitudes. The 50° isothermal of the southern hemisphere extends through the southern extremity of Chili and New Zealand.

Colours have been employed, in order to make different regions of the globe with the same mean annual temperature more easily to be compared with each other. Three great zones are distinguished; of which, the Torrid and Frigid Zones are in different tints, the deepest red and blue denoting the very hottest and coldest districts of the globe. We thus see at a glance which countries possess a climate similar to that of Europe, and which countries are included within the Torrid or Frigid Zone.

On comparing this Map with the preceding one of the Ocean Currents (No. VI.), their intimate relation, and the great influence of the currents on the distribution of temperature will be evident. Of these, the Peruvian current, the Arctic or Cold current, the North African and Guinea currents, and on the other hand the Gulf-stream, are among the most remarkable, one portion absorbing the existing heat, the other diffusing a genial warmth. In tracing these currents, several of the most important deviations or irregularities in the isothermal lines will readily be accounted for. There is, for instance, the great bend between the Canary Islands and the North Cape, and the still greater one between this latter point and Ireland, which is owing to the combined influence of the Gulf-stream and Arctic current; the former, with its warm waters, sweeping N.E., along the European coasts, the latter, with its cold waters, to S.W., along the opposite American coasts, thus:

the isothermal of the Map, affected by both currents, that of 30°, reaches, in the north of Europe, a latitude of 73°, while the same in Asia and America extends as far south as the parallel of 52° and 50°. In Europe, then, the mean annual temperature of North America and Asia, in a certain latitude, extends 22° or 23°, or about 1600 English miles further north; and our country is thus blessed with a temperate zone of about double the latitudinal extent of other parts of the globe.

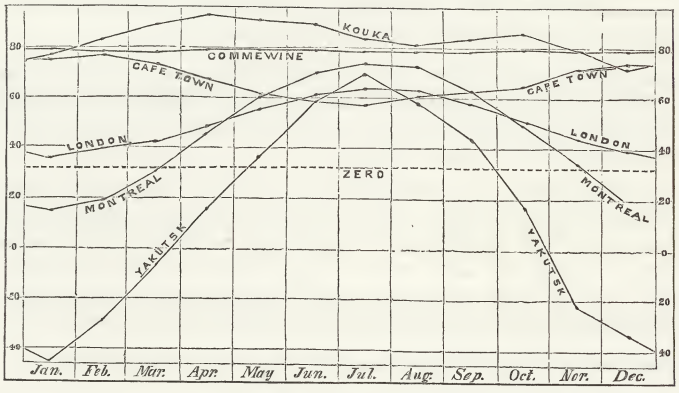
The Gulf-stream and Arctic current are indicated in the Map as being so extremely striking in their effect, and particularly so from the quantity of floating Polar ice, which would regularly drift to our own islands, were the Arctic current on this side of the ocean; but as it is, the Gulf-stream keeps the European shores entirely free from this Polar visitation. Iceland, from being situated on the boundary-line between the two currents, forms an interesting point for observing their effects in close contiguity. While the south-eastern portion of this island possesses a mean annual temperature of about 42°, a temperature which is reached by no other country of the globe in the same latitude, in the northern part, washed by the cold current, it is as low as 33°, and in the western part it must be still much lower. In certain seasons, when large masses of ice surround these coasts and remain till late in summer, the most disastrous consequences ensue, sometimes causing famine over the whole island.* The Bear Island, too, is an interesting point of meteorology or rather hydrography, for it is proved in L. Von Buch's excellent memoir,† that the influence of the warm Gulf-stream extends as far as this island; a mild air prevails during south-westerly winds, and the months of November and December bring rain rather than snow,—a remarkable circumstance in an island lying in the very same latitude with Melville Island, actually one of the coldest spots on earth!

Thus isothermal lines bring vividly before us the great features of the distribution of temperature; but isothermals of the *whole year*, as hitherto constructed, and as generally meant under that denomination, effect this only on the very broadest principles of generalization, and may be regarded as the foundation-stone, laid by the great Humboldt, of that important science, Meteorology. For to know the exact climate of a certain

* Waltershausen, "Physisch-geographische Skizze von Island," 1847. † Buch, "Die Bäeen-Insel," 1847.

METEOROLOGY:—MAP VII.

place, it is not sufficient to know its mean annual temperature, but rather how this is distributed in its several months and seasons, as the diversity in these particulars which takes place in different parts of the globe is extremely great. For example; the isothermal of 50° goes through London, and cuts the northern part of the Caspian Sea, the southern extremity of the Canadian lakes, etc.; yet London can neither boast of the grapes which Astrakhan produces in finer quality than even Spain or the Canary Islands; nor of the ice on the other side of the Atlantic, which is actually brought to London;* the winters of these places being much colder, and their summers much warmer. It is evident, therefore, that in order to gain a very complete idea of the distribution of temperature, isothermals of the hottest and coldest month, or of every month, ought to be constructed; such a plan was not adopted for the present Map, partly because yearly isothermals are sufficient for the first general view, and partly because materials were wanting for the construction of such lines. † But in the enlarged Map of the British Isles (No. XIV.) it has been attempted to lay down monthly isothermals. The following graphical view is given to show the remarkable diversities of thermometric range, within the twelve months, of some places of the globe:



The annual means of the six places in the Diagram are (according to Dove's last Tables): Kouka, 83°·6; Commewine, 78°·1; Capetown, 66°·5; London, 50°·1; Montreal, 45°·8; Yakutsk, 13°·4. While these curves diverge most in the winter months, they approach each other considerably in summer; in August the difference between the extreme lines (Kouka and Yakutsk) is only 22°, while in January it is 124° (Commewine and Yakutsk). The terrible January cold of the latter place is not corresponded to by any equally cold point in North America,‡ nor by any other parts of the globe, yet its July temperature rises 5° higher than London; while the latter coinciding with Montreal in April and October is 21° warmer in January. In Commewine, a heat of 77° to 79° prevails throughout the whole year; in Yakutsk, it deviates 114° in the different months, which is times more than in London.

* Wenham Lake, the celebrated depôt for ice, is situated about 1½° north of the London isothermal. For exact position, *see* "Milner's Atlas of Political Geography," sheet, United States.

† When this map was constructed, Dove's extensive tables, which would have supplied the desired materials, were not yet published. These tables, and the maps, recently published (September, 1849), with *isothermals of every month*, mark, undoubtedly, a most important epoch in the history of meteorological science, as they not only contain the results of all observations made (amounting to perhaps seven millions of single observations), but also the extremely important deductions arrived at after many years' researches by the distinguished author.—As Dove does not give a map with yearly isothermals, the present one may be considered as the most complete, being based on between 500 to 600 stations, by far the greater part from the tables in "Humboldt's Central Asia," German edition, 1844, which, though compiled by Mahlmann, were derived principally from Dove's labours. Berghaus constructed his maps from only 307 stations.

‡ Reports of the British Association, 1848–49.

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METEOROLOGY.

VIII. MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF THE WINDS, AND THEIR INFLUENCE ON NAVIGATION.

WITH

SKETCH, SHOWING THE LIMITS OF THE TRADE-WINDS IN THE SEASONS.
NOTE ON MAURY'S CIRCLE SAILING.

This sheet offers a view of the great movements of the air; the region of variable winds and calms distinguished by red colour, the regions of the trade-winds by green, those of the prevailing south-west and north-west winds by yellow, and those of the monsoons by blue; lastly, the districts of the hurricanes, &c., are marked by orange colour.

These different regions in their extent are not so distinctly marked in nature as they are drawn on the Map, for their limits are continually shifting from season to season, even from day to day. The lines of the Map represent the mean of the whole year, in order to gain a comprehensive idea by the broadest generalization; for example, the polar limit of the N. E. trade-winds in the Atlantic is laid down in 28° north latitude, expressing the yearly average, while in summer it is in $30\frac{3}{4}$° N., and in winter in $24\frac{3}{4}$° N.; a difference of more than 400 miles. In the Pacific this variation seems still more considerable, the equatorial limit of the north-east trade-wind being in summer $11\frac{1}{2}$° N. lat., in spring, $\frac{1}{4}$° S. lat.; which implies a difference of $11\frac{3}{4}$ degrees, or upwards of 800 miles. The approximate limits of the different seasons both in the Atlantic and Pacific are laid down in the small separate Map at the bottom, the four seasons being distinguished by colours; blue denoting winter, and so forth. From this sketch, it appears that in the Atlantic the region of calms is to be found permanently but in a very narrow belt; viz., from $3\frac{1}{4}$° to $5\frac{3}{4}$° N. latitude.

The data on which the lines in the small sketch are based, will be found in the Table at the top of the Map; they are the results of Berghaus's* extensive researches, chiefly from observations made by Prussian vessels. Recently the investigations on this subject have been considerably extended by the important labours of Lieut. Maury†, who has begun to lay down on large charts thousands of observations relating to winds and currents of the ocean; indeed on so grand a scale as will ultimately prove of the utmost importance to navigation. Some of the practical results he has already obtained are embodied in the Map. Three strong lines, marked *a b c* (*see* North Atlantic Ocean,) denote new and more advantageous routes proposed by him. The average passage from New York to Brazil is forty-one days; by the new route, which is considerably more eastward (see line *c* on Map), it is much shorter; the mean of four vessels which have tried the new route is thirty-one days, the shortest being twenty-four, the longest thirty-nine days.‡ There is reason to believe that the prevailing winds along this new route will be found more favourable, steadier, and stronger than they are by the usual route, and the distance is 1000 miles less.

The region of calms in the Atlantic scarcely extends to the American shores, but is confined chiefly to the eastern portion. Here, between the African coast and long. 25° W., Maury found, of 2292 observations, 246 with calms, and by far the greater number, viz. 951, with southerly or westerly winds. This direction is exactly opposite to that of the N.E. trade-winds. Hence, atmospherical disturbances are created, and facts show this region, known to sailors as the Equatorial "doldrums" (see Map), to be one of violent squalls, sudden gusts of wind, of thunder-storms, heavy rains, lightning, baffling airs, and calms. Most vessels bound from the United States to any port beyond the equator, steer almost an east course, making the Canaries or Cape de Verde Islands, and then shape their course through this region. By the proposed route this would be entirely avoided.

The districts of the hurricanes (marked orange in the map) show the strikingly analogous feature in their occurrence, of all of them being inter-

* For the Atlantic, (*see* his "Physikalischer Atlas;" for the Pacific his "Länder und Völkerkunde.")

† Maury, Wind and Current Charts of the Atlantic, 1848.

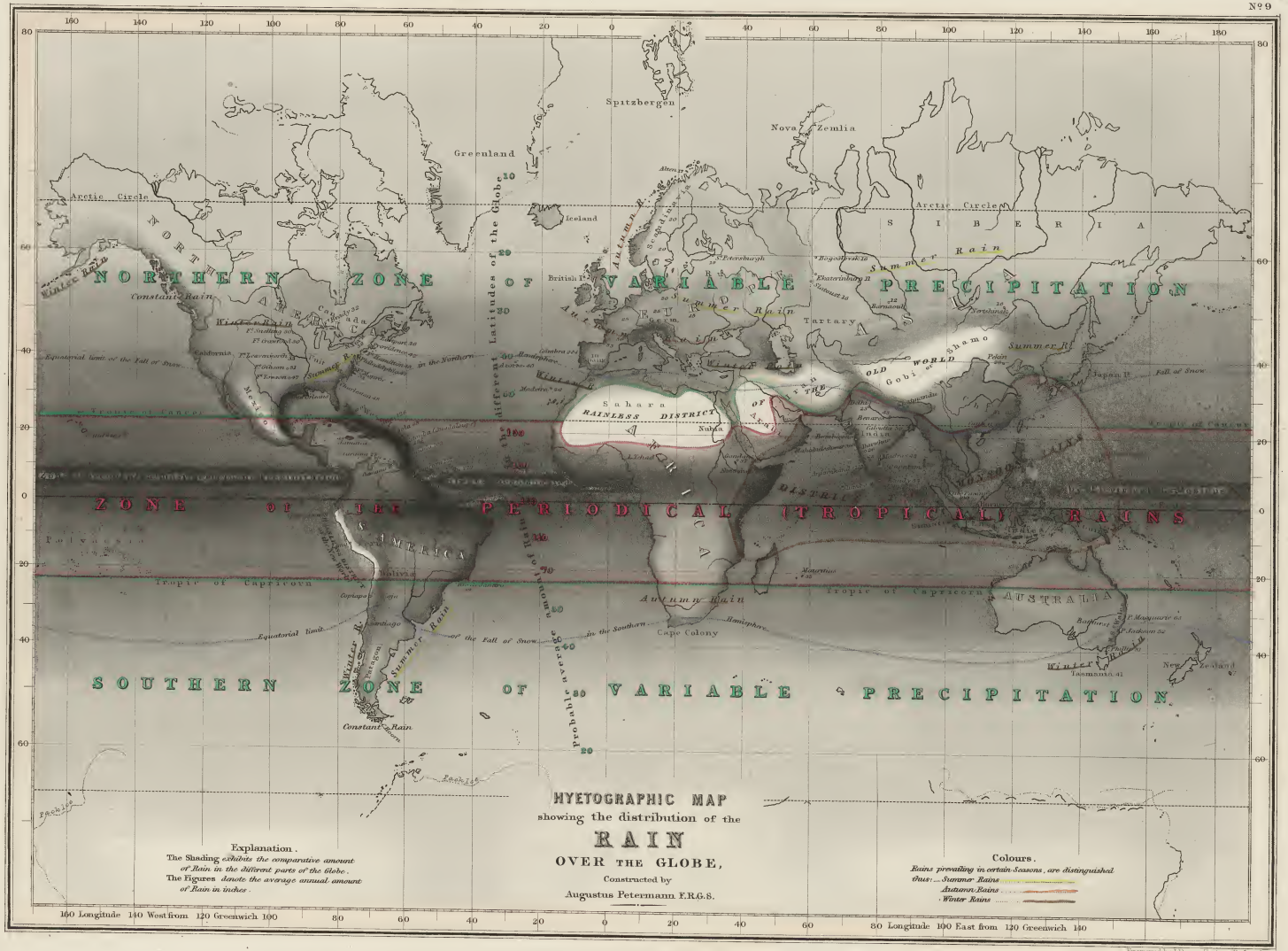
‡ Maury, Observations on his Charts, (see "Reports of the British Association, 1848.")

METEOROLOGY:—MAP VIII.

sected by the tropics. The coloured centre denotes their focus, or that region which is most regularly and frequently visited, while the narrow outer lines comprise the farthest points to which hurricanes on record have extended. The rotatory motion of the hurricanes is indicated in their focus by a curved arrow.

The faint lines indicate the great trade routes and steam-packet tracks between various parts of the globe. On this point, also, Maury has suggested important facilities in the routes between distant lands; his proposed circle from Panama or California to China, it is said, would enable the merchant in London to receive news from China in sixty, and perhaps even in forty-five days. If we examine, he says,* the course and distance as they appear on Mercator's Chart, which is the projection used in navigation, we shall find the distance to be about 9500 miles, and the course to be by the way of the Sandwich Islands. But on Mercator's Chart the surface of the earth is represented as a plane, and is therefore distorted. The shortest distance between any two places, unless they both be on the Equator, or the same meridian, is along the arc of the great circle in the plane of which the places are situated. Now if we take a common terrestrial globe and draw a string tightly across it from Panama to Shanghae, it will show the shortest distance between the two places, and will represent the great circle route between them; and this string, so far from touching the Sandwich Islands, will pass through the Gulf of Mexico, thence through Louisiana towards Oregon, crossing the ocean several thousand miles to the north of them (see Map.) This route, were it practicable to travel it, is 8200 miles, or about 1200 miles less than it is by the way of the Sandwich Islands: the next step, therefore, is to find a route practicable. By still holding one end of the string at Shanghae on the globe, and carrying the other end until it will just clear the peninsula of California, we shall have an arc of a great circle along which a steamer with fuel sufficient might sail all the way from Chili to the Islands of Japan, without ever having to turn aside for the land. This, therefore, is the shortest route, and the nearest navigable distance to China for all vessels from the western coasts of America, from Cape Horn to California. Monterey is recommended as the most suitable harbour on the Californian coasts to start from.

* "Athenæum," May 6, 1848, p. 460.



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METEOROLOGY.

IX. MAP, SHOWING THE DISTRIBUTION OF THE RAIN OVER THE GLOBE.

This Map represents, by different tints of shading, the comparative amount of rain that falls in various localities of the globe; the deepest tints denoting the greatest quantity, and the blank spaces the rainless districts. The enormous diminution of the average annual quantity of rain from the equator to the poles will be observable at a single glance: a careful investigation and comparison of the rain-observations hitherto made gives an average amount of 150 inches under the equator, and 10 inches in lat. 70° N. The absolute greatest quantities of the yearly fall of rain have been observed in the following places:

Tropical America: . .	Matouba (Guadaloupe)	292 inches.
Tropical Asia: . . .	Mahabaleshwar (Western Ghauts) . . .	303 „
Tropical Africa: . .	Sierra Leone	313 „

The latter amount of 313 inches in Sierra Leone occurred in the year 1828,* from the 8th of June to the 31st of August; and, as this is only a portion of the rainy season,† the total amount in this year may safely be estimated, in round figures, at 400 inches—an enormous figure, which appears still more so from the fact, that in two successive days, on the 22d and 23d August, the quantity was 26 inches; which is more than falls in the eastern portion of Great Britain throughout the whole year!

The shading, though affording an extremely striking and conspicuous general view of the amount of rain, is quite insufficient to represent accurately the various tints ranging between 1 and 300; therefore *figures* have been inserted in the Map, expressing definitely the average quantity of rain observed in various parts of the globe. There is: 1, a scale of coloured figures from north to south across the Atlantic, which gives the average amount for the various latitudes of 10° to 10° as far as 60° and 70°, beyond which no observations have yet been recorded; 2, there are small figures denoting that of certain districts; and 3, others which only denote that of certain places. For example, in Spain 10 expresses the average amount of rain in the interior of the whole country, while 224 denotes that at Coimbra only.

From the comparatively small number of figures in the Map, our defective knowledge of the absolute amount of rain in many countries of our planet will be apparent; but it must be borne in mind that hyetometric observations have only recently begun, and that our knowledge is daily augmented. Since 1840, when Berghaus, the great compiler of physical data, published his list of all observations then recorded, the number has been nearly doubled. The following are some of the most important and trustworthy:

AMOUNT OF RAIN IN THE UNITED STATES OF NORTH AMERICA.‡

(The following data are means of observations made during three, four, and more years.)

	Latitude.	Longitude.	English Inches.
Fort Brady, outlet of L. Superior	46° 39′	84° 43′	31·89
Hancock Barracks, Maine	46 10	67 50	36·92
Fort Snelling, confluence of St. Peters and Mississippi . . .	44 53	93 8	30·32
„ Howard, Wisconsin	44 40	87 1	38·83
„ Winnebago, Wiscon. Ter.	43 35	89 30	31·88
„ Constitution, N. Hampshire	43 5	70 45	28·85
„ Crawford, Wisconsin	43 3	90 53	29·54
Watervliet Arsenal, N. York	42 30	73 13	34·22
Dearbornville, Michigan	42 22	82 55	31·30
Watertown, Massachussets	42 21	72 12	39·69
West Point, N. York	41 22	73 57	48·70
Fort Wood, Harbour of N. York	40 43	74 01	47·90
„ Hamilton, Harbour of N. York	40 43	73 56	45·71
Alleghanny Arsenal, Pittsburgh, Pennsylvania	40 26	80 02	28·14
Fort Leavenworth, Missouri	39 20	95 05	32·68
„ McHenry, Baltimore, Maryland	39 17	76 36	40·80
Washington, city	38 53	76 55	34·62
St. Louis, Missouri	38 40	90 10	24·12
Fort Monroe, Old Point Comfort, Virginia	37 2	76 12	52·55
„ Gibson, Arkansas	35 47	95 10	30·64
„ Smith, ditto	35 30	94 25	35·64
„ Towson, ditto	33 33	94 55	46·73
„ Jesup, Louisiana	31 30	93 47	47·43
New Orleans	29 57	90 14	51·85
Key West, near C. Sable	24 33	81 52	31·89

* Parliamentary Reports on the Sickness, Mortality, and Invaliding among the Troops of Africa, 1840.—The quantity in the different months was: June 8th to 30th = 64·55 in.; July = 125·25 in.; August = 123·70 in.

† It sets in about the latter end of April or beginning of May, and breaks up about September or October; occasionally rains occur in November and December, but they are most violent in July and August. (*See* "Shreeve, Sierra Leone," 1847, p. 56.)

‡ Forry, "Climate of the United States," 1842.

METEOROLOGY:—MAP IX.

RUSSIAN EMPIRE AND CHINA.*

St. Petersburgh (1841—1844, mean)	19·02 Inches.	Slatoust (1841—1844)	15·88 Inches.
Ekaterinburg (ditto)	10·95	Bogoslovsk (ditto)	15·92
Barnaoul (1842—1844)	12·00	Lougan (ditto)	15·67
Nertshinsk (ditto)	17·25	Pekin (1841 & 1842)	28·42

Lougan lies in 48° 35′ N. lat., 39° 21′ E. long.; for the position of the other places, see Map.

NEW SOUTH WALES AND TASMANIA†.

Port Macquarie (N. S. Wales)	62·68	Woolnorth (Tasmania)	43·75
Port Jackson (ditto)	52·42	Circular Head (ditto)	35·42
Port Philip (ditto)	30·72	Port Arthur (ditto)	44·69

BRITISH ISLES.

(All hyetometric observations hitherto made in the United Kingdom are given in "Petermann's Hydrographical Map of the British Isles," 1849. The stations of observation amount to the number of 116.)

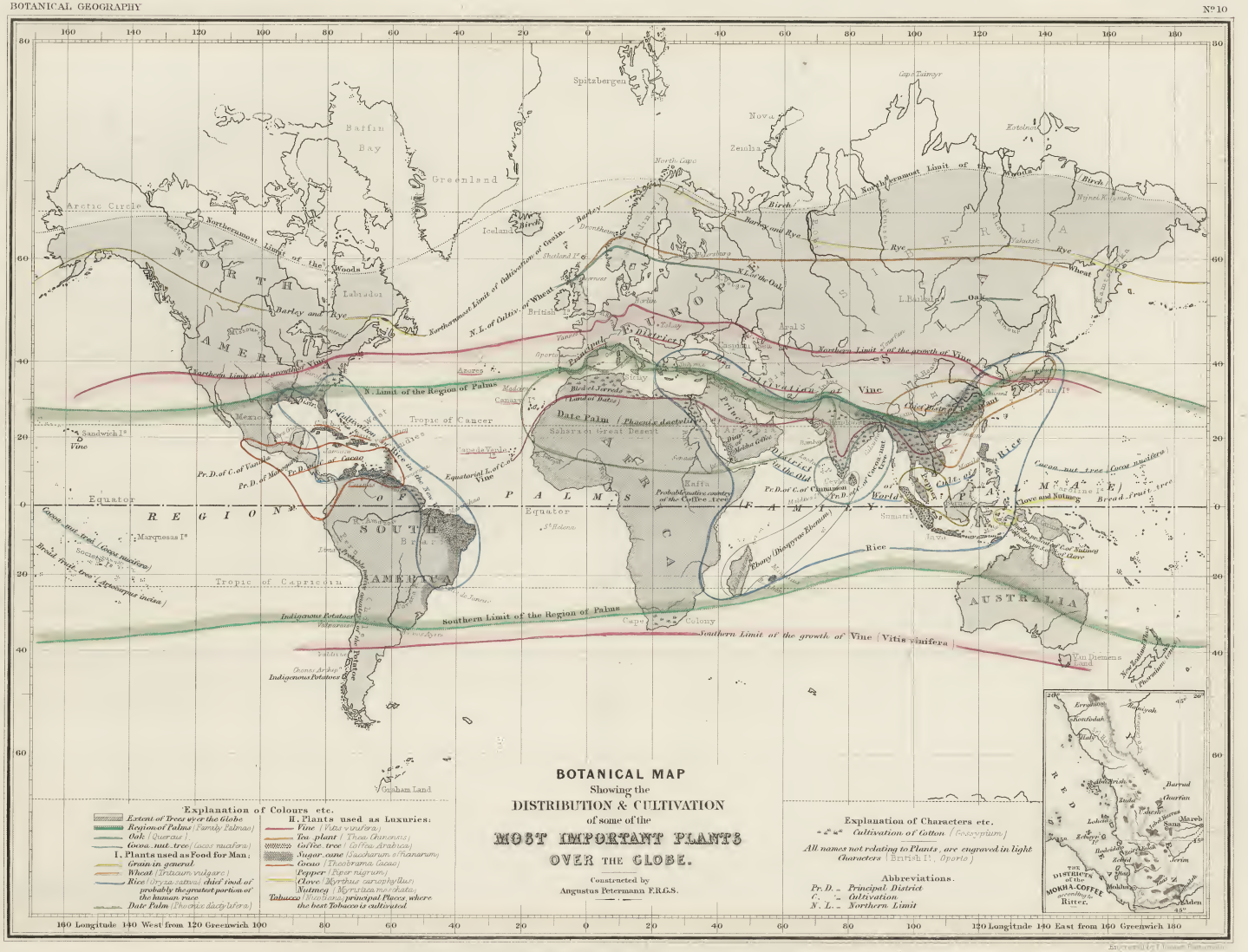
Snow.—The *limits of the fall of snow* towards the equatorial regions (disregarding mountains) are indicated by blue lines. The main points of the line in the northern hemisphere are adverted to in the letterpress (p. 51); it may be added that it snows in California, Mexico, and the southern part of Palestine; snow-storms also are frequent in Persia. In the Southern Hemisphere, snow falls at Santiago, though rarely;‡ in the Plains of La Rioja§ still more rarely. In the Cape Colony the mountains are not unfrequently covered with snow, but it sometimes occurs also in the valleys of Albany and the eastern districts; in Tasmania a good deal of snow falls in the interior, and in Bathurst (N. S. Wales) heavy snow-storms are common; while in the Swan River Colony snow is unknown, though hailstones of a very large size occasionally fall. Of the *amount of snow* that falls in colder countries, few observations have yet been made; but from the excellent observations made by order of the Russian government, and of which the general results are given in the above Table, it appears that the quantity of snow in Southern Siberia is comparatively small to that of rain:

	Total fall of rain and snow.	Fall of snow.
St. Petersburg (1841—1844, mean)	19·02 in.	5·28 in.
Ekaterinburg (1842—1844 „)	12·31	1·54
Barnaoul (ditto)	12·00	1·23
Nertshinsk (ditto)	17·25	2·32

* Kupffer, "Annuaire Magnetique et Météorologique," 1847.

† Strzelecki, "New South Wales," 1845. ‡ Macgregor, "Progress of America," 1847.

§ "Journal Royal Geog. Soc. of London," vol. ix., p. 381.



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BOTANICAL GEOGRAPHY.

X. MAP, SHOWING THE DISTRIBUTION AND CULTIVATION OF SOME OF THE MOST IMPORTANT PLANTS OVER THE GLOBE;

WITH

SKETCH, SHOWING THE DISTRICTS OF THE MOKHA COFFEE.

In order to give a general and systematic view of the vegetable kingdom in its distribution over the globe, certain botanical regions have been established according to plants peculiar to them or predominant in them. Willdenow was the first, who, about the beginning of this century, attempted such a division of the earth's surface; after him, Treviranus, Decandolle, Schouw, and Martius.

Decandolle	adopted	20 regions.
Schouw	„	25 kingdoms.
Martius	„	51 provinces.

In the Map, the chief purpose of which is to show the districts and boundaries of some of those plants most important to man, either as food or for his comfort, only three regions or zones are distinguished:

Region of the Palm-tree (distinguished in the Map by the darker shading and green boundaries.)
Region of the Pine, and other trees (distinguished in the Map by the lighter shading.)
Region without trees (left blank in the Map.)

On these shaded regions the districts of the various food-plants and others are shown by lines mostly coloured, or by other signs, such as bold dotting for the coffee, cross-ruling for the sugar, and little groups of lines for the cotton districts.

In viewing the distribution of plants according to the botanical regions determined on by the above-mentioned authors, of which that of Schouw has most generally been adopted, the leading characteristics depend chiefly on the smaller organs of propagation, the flowers, and the fruit. But if the vegetable kingdom be viewed according to the aspect which it gives to the various parts of our globe, very different groups or divisions will be recognised. Humboldt, the great founder of the Geography of Plants, describes nineteen characteristic forms of vegetation,* which are principally concerned in determining the aspect or physiognomy of nature.

The Palms, the loftiest and noblest of all vegetable forms; that to which the prize of beauty has been assigned by the concurrent voice of nations in all ages. Europe only comprises a single representative, the true climate of Palms having a mean annual temperature of 78° to 81½°.

The Plantains or *Bananas* everywhere accompany the Palms. Their low and succulent stems are surrounded by delicately-veined leaves, of a bright and beautiful verdure. It is on their fruits that the subsistence of a large part of the inhabitants of the torrid zone chiefly depends.

The Malvaceæ and *Bombaceæ* have enormously thick trunks, large soft leaves, and superb flowers, frequently of a purple or crimson hue. It is to this group that the Baobab, or monkey bread-tree belongs. In Italy the Malvaceæ already begin to impart to its vegetation a peculiar southern character.

The Mimosæ, with its delicately pinnated foliage, is entirely wanting in the temperate zone of the Old Continent, though found in the United States: but

The Heaths belong more especially to the Old World, and particularly to the African continent and islands. Arborescent heaths extend to the northern shores of the Mediterranean. Of the 300 known species of Erica, only one has been discovered in America.

The Cactus form, on the other hand, is almost exclusively American. It comprises some of the plants to which the term of "vegetable fountains in the desert" has been applied.

* Humboldt, "Aspects of Nature," 1849; vol. ii.

BOTANICAL GEOGRAPHY:—MAP X.

The Orchideæ (to which the Vanilla belongs) enliven the clefts of the wildest rocks, and such is their number and variety that, to mention only a limited district, the entire life of a painter would be too short for the delineation of all the magnificent Orchideæ which adorn the recesses of the deep valleys of the Andes of Peru.

The Casuarinæ, leafless trees, like almost all species of Cactus, are found only in the islands of the Pacific and in India.

The Needle-trees in the colder latitudes, cheer the desolate winter landscape with their never-failing verdure. The greater number of these trees are found in all temperate and cold climates.

The Pothos-plants, clothing parasitically the trunks of aged and decaying forest-trees, prevail chiefly in the tropical world, and extend to the Spanish and Italian shores of the Mediterranean. To these are frequently associated, in the hottest part of South America,

The Lianes, those twining rope-plants, which display in the tropical regions the utmost vigour of vegetation. On the oanks of the Orinoco their leafless branches sometimes hang down perpendicularly from the high top of the Swietania, forty to fifty feet long. The Lianes chiefly belong to America.

The Aloes, strikingly different from the latter, are either without stems altogether or have branchless stems. They are principally confined to the torrid zone, and stand singly in arid plains, imparting to the landscape a melancholy character. Their mournful repose and immobility contrasts with the airy grace and tremulous lightness of

The Gramineæ, which have a wide range of distribution. The arborescent grasses (Bambusaceæ) are among the most beautiful adornments of the tropical world.

The Ferns extend from the equator to the polar countries, as Greenland and Iceland; but in the hotter parts of the globe they become ennobled, arborescent ferns reaching a height of forty feet.

The Liliaceous Plants, with their flag-like leaves and superb blossoms, are confined chiefly to Southern Africa.

The Willow form is indigenous in all parts of the globe, but the leading representative, the willow itself, only in the northern hemisphere.

The Myrtaceæ extend, in the New World, from 26° N. lat., to 56½° S.; in the Old World from 46° N. lat. (in Europe), to 50½° S. lat. (Auckland Islands.)

The Metastomaceæ are confined to tropical America.

The Laurel form, most numerous in South America.

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ZOOLOGICAL GEOGRAPHY.

XI. MAP, SHOWING THE DISTRIBUTION OF THE PRINCIPAL MAMMIFEROUS ANIMALS OVER THE GLOBE;

WITH

LISTS OF THE ANIMALS REPRESENTED, GIVING THEIR NAMES, ORDERS, AND SPECIES.

In this Map it is attempted to represent in a popular manner the distribution of the principal Quadrupeds or Mammalia. Two methods are employed; small types of the animals are inserted in such parts of the Globe where they principally occur. In cases where they have a very wide range, these types are either repeated or coloured lines are drawn, denoting the extreme limits to which they extend. Where the occurrence of animals is only indicated by the types, these are merely numbered, and referred to in the Tables at the bottom of the Map, in order to avoid confusion and over-fulness of writing. Each of the eight orders has its representative in the Map, selected from the more important, characteristic and well-known species. Their number, in the Old World, is 50, and in the New World, 25.

Zoological Geography, with other branches of this extensive Science, has made very rapid strides within the last ten years. Of comprehensive labours, previous to Wagner's, respecting the vertebrated animals, those of Pompper, Keyserling, and Blasius, and, above all, Berghaus's, are the most important; but while Berghaus, in 1843, adopted 1,500 as the extreme number of species of the Quadrupeds, there are, at present, nearly 2,000 species, or one-third more, known and described, and instead of 6,000 species of Birds, at least 8,000:—such is the number which Gray, in the preface to his magnificent work,* considers entitled to be enumerated.

Wagner's researches,† as already alluded to, are the most valuable, not merely of the last ten, but of the last forty years; namely, since Illiger's excellent treatises on the Geographical Distribution of the Mammalia, in 1811. Wagner's labours, like Illiger's, comprise the entire class, in its distribution over the globe, and are based on systematic discrimination and scientific knowledge. When Zimmermann, in 1783, laid the foundation of this branch of science, he counted 400 species; thirty years after, Illiger reckoned 800. Since then, so many new species of the smaller Quadrupeds have been discovered, such as Bats, Mice, Squirrels, and Rodents in general, that from 800 the number has increased to 2000. Estimating the class of Reptiles as having a proportionate increase with the other two classes, we obtain the following general result:—

	Species in 1832, according to Bonaparte.	Species in 1843, according to Berghaus founded on Oken.	
Quadrupeds	1149	1500	1967 (according to Wagner and Waterhouse in 1846 & 1848)
Birds	4109	6000	8000 (according to Gray in 1849)
Reptiles	945	1200	1600 (estimated in 1849)
			11,567

The following Table, giving the complete Mammalian Fauna of the great quarters of the Globe, is carefully compiled from Wagner's labours, with the exception of the Rodentia, which are taken from Waterhouse's list. ‡

TABLE SHOWING THE DISTRIBUTION OF THE MAMMALIA OVER THE GLOBE.

Orders, with the Number of their Species.	Europe.	Asia.	Africa.	Australia and Polynesia.	N. America.	S. America, including Central America.
	Number of the Species. (Those in parentheses denote the amount peculiar to each country.)					
I. Monkeys (*Simiae*) 186	1	49 (49)	63 (62)	—	—	74 (74)
II. Carnivorous Animals (*Carnivora*) 731	64 (20)	276 (224)	174 (151)	8 (8)	101 (88)	188 (180)
III. Pouched Animals (*Marsupialia*) 140	—	4 (4)	—	105 (105)	4 (3)	28 (27)
IV. Gnawing Animals (*Rodentia*) 604	61 (21)	185 (126)	104 (94)	21 (19)	118 (113)	166 (161)
V. Toothless Animals (*Edentata*) 34	—	5 (5)	6 (6)	3 (3)	1 (1)	20 (19)
VI. Thick-skinned Animals (*Pachydermata*) . . 38	1	17 (16)	18 (17)	—	—	4 (4)
VII. Ruminating Animals (*Ruminantia*) . . . 159	14 (7)	67 (59)	65 (62)	—	13 (9)	13 (12)
VIII. Cetaceous Animals (*Cetacea*) 75	24 (7)	29 (9)	16 (7)	13 (3)	23 (4)	25 (14)
Total amount of the Species **1967**	**165** (55)	**632** (492)	**446** (399)	**150** (138)	**260** (218)	**518** (491)

* Gray, "The Genera of Birds," (illustrated by Mitchell,) 1844—1849.

† Wagner, "Die Geographische Verbreitung der Säugethiere," in: Abhandlungen der Akademie der Wissenschaften zu München, 1844—1846.

‡ Waterhouse, "List of the Rodentia, with their Geographical Distribution," in Johnston's Physical Atlas, 1848.

ZOOLOGICAL GEOGRAPHY:—MAP XI.

From this Table the fact will be strikingly evident, that each grand division of the globe has Mammals, which are either wholly, or for the most part peculiar to it. Continents separated from others by the broad ocean differ naturally most in this point, and Australia has of 137 species of its Land Mammals only two species in common with other countries, viz: the Black and Brown Rat.

Europe. This division contains comparatively the smallest number of species peculiar to itself, but this is explained by its close connexion with Asia, which makes it very difficult to draw any exact line between their respective Faunas. The characteristic features in the European Fauna are, the entire absence of the two orders of Marsupialia and Edentata, while of two other orders, Simiæ and Pachydermata, only two species are found.

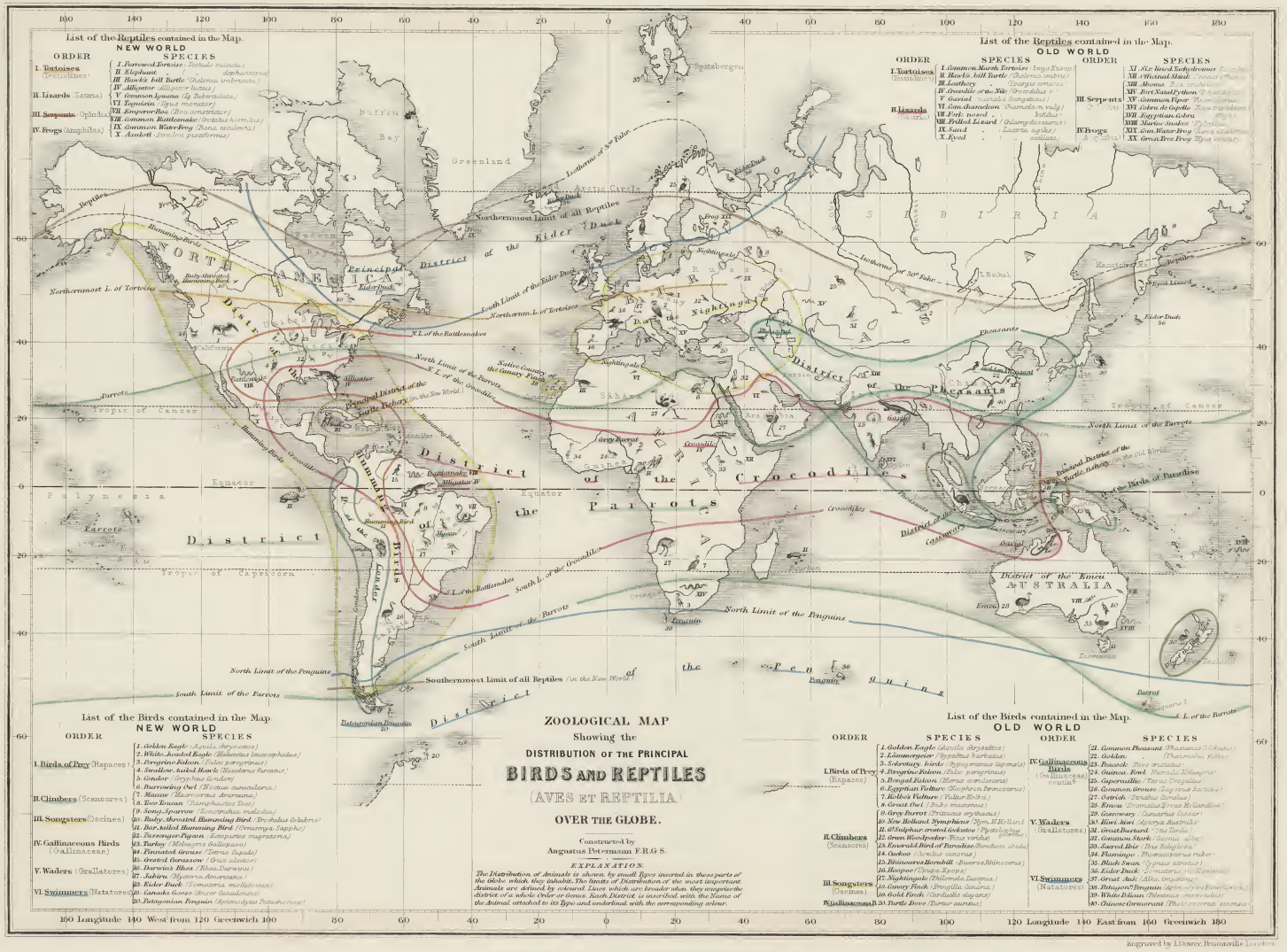
Asia, from its superficial extent, and from the diversity of soil and climate, contains a greater number and variety of Mammals than any other quarter of the Globe. Nor is it only their number and variety that claims particular attention; their intrinsic value in the economy of human society, the prominent part which they have played in the early civilization of mankind, make the consideration of Asiatic Zoology an object of interest not less to the historian, the antiquary, and the general inquirer, than to the Zoologist. In fact, the great majority of the domestic animals which enabled man to till the earth, to extend his power, and to transport his commodities to distant regions, are of Asiatic region:—The horse, the ass, the dog, and others, are all of eastern derivation; the greatest number of species of Ruminantia, Carnivora, and also Rodentia and Cetacea are found in this division.

Africa is richest in the number of its Pachydermata; the Ruminantia also are nearly as numerous as in Asia, while that of the monkeys is much greater. The Hippopotamus and Giraffe are amongst the most striking and characteristic of the African Mammals.

North America's Mammalian Fauna is not more different from that of Asia and Europe, than it is from that of South America; this may be partly attributed to the similarity in soil and climate between the former, and also, perhaps, their proximity at Behring's Strait. We find the common bear, the wolf, the fox, the rein-deer, and others, equally in Sweden, Siberia, and Northern America. The most peculiar feature in its Fauna is the entire absence of the monkeys so abundant in South America, as well as of the Pachydermata and Edentata, of which latter only one species occurs; the Marsupialia are also very scantily supplied, so that, in fact, of the Land Mammals, only the three orders, Carnivora, Rodentia, and Ruminantia occur in considerable numbers.

South America, as already observed, is very different from North America, but it is still more so from the other Tropical countries, as Africa, Asia, and Europe. Those large Mammals, as the elephant, rhinoceros, hippopotamus, giraffe, camel, are entirely wanting, even the horse, ass, sheep, goat, were not indigenous; whilst their place is occupied by the singular order, to which the sloths, ant-eater, and armadillo, belong.

Australia has quite a Fauna of its own, not only that it is destitute of quadrumanous animals, but also of pachydermata and ruminants; that is, of all those species which are best adapted for human food, and for the various purposes of social economy,—a circumstance in which we read the history of its aboriginal inhabitants, their comparative small number, and the abject and degraded misery in which they have generally been found. The Marsupials comprehend the great majority, and form the principal character of the Australian Mammals.



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ZOOLOGICAL GEOGRAPHY.

XII. MAP, SHOWING THE DISTRIBUTION OF THE PRINCIPAL BIRDS AND REPTILES OVER THE GLOBE;

WITH

LISTS OF THE ANIMALS REPRESENTED, GIVING THEIR NAMES, ORDERS, AND SPECIES.

While the preceding Map represents the first class of the vertebrated animals, the Mammals, the present gives outlines of the distribution of the next two classes, the Birds and Reptiles. It is constructed on the same principle; the districts of some of the most important species or groups being shown by coloured lines; the principal habitat of others being indicated by small types. No less than ninety different species are thus shown on the Map, and enumerated in the Tables in each corner. There are, as among the Mammals, particular species or groups confined to certain regions; others have a wide range, and extend almost round the whole globe, within a certain Zone. To the latter class belong the crocodiles and parrots, chiefly in the Torrid Zone, though the parrots extend also into the temperate regions, especially in the New World. Others are peculiar to the Old or New World, to the Northern or Southern Hemisphere; as, for example, the humming-birds occur only in America, the nightingale in the Old World; the emeu is peculiar to Australia, the ostrich to Africa, the condor to America, while the most beautiful of the feathered tribe, the birds of Paradise, are limited to the Island of New Guinea; the penguins are characteristic of the Antarctic, the eider duck of the Arctic regions; rattlesnakes are only found in the New, vipers only in the Old World.

The geography of the Birds and Reptiles has not been so completely investigated as that of the Mammals, and it is scarcely to be wondered at, considering the greater difficulty of the subject; for not only does the class of Birds contain four times more species than the Mammals, but from their powers of locomotion the geographical distribution is also less easy to define. Statistical data are therefore very defective. The most recent work comprising the geographical distribution of Birds and Reptiles over the globe is that of Pompper,* from which the following general Table has been compiled; and although that work is far from containing the whole of the species known and described at present, still it gives the approximate proportion of the Ornithological and Erpetological Faunas of the various regions of the globe, a point of primary importance in Zoological Geography. Pompper does not sum up the total amount of species of the great quarters of the globe, as we have done in the preceding Map, but enumerates the Fauna of 18 different provinces into which he has divided the surface of the globe, and which made it necessary to adhere to his arrangement. The limits and extent of these 18 Zoological provinces, grouped according to the Continents, are given in the following list:

	AMERICA.		
1.	*Arctic America*	comprising,	British and Russian America, Greenland.
2.	*North America*	„	United States (with Texas, California, etc.)
3.	*Central America*	„	Mexico, Central America Proper, West Indies.
4.	*Tropical America*	„	Colombia and Peru, Bolivia and Brazil, as far as 15° S. lat.
5.	*South America*	„	Southern portion of Peru, Bolivia and Brazil, La Plata, northern part of Chili.
6.	*Austral America*	„	Southern part of Chili and Patagonia.
	EUROPE.		
7.	*Arctic Europe*	„	Iceland, Scandinavia, Nova Zembla, northern part of Russia to about 55° N. lat.
8.	*Central Europe*	„	British Isles, France, Germany, Southern Russia.
9.	*Southern Europe*	„	Spain, Italy, Turkey, Greece.
	AFRICA.		
10.	*Northern Africa*	„	Barbary, Sahara, Egypt, Nubia, Arabia.
11.	*Central Africa*	„	Senegambia, Southern Guinea, Abyssinia, &c., as far as lat. 10° S.
12.	*Southern Africa*	„	Cape Colony, Madagascar, to the north as far as 10° S.
	ASIA.		
13.	*Arctic Asia*	„	Siberia.
14.	*Central Asia, northern part* .	„	Turkestan, Mongolia, Manchouria, Tarakai, Yeso.
15.	*Central Asia, southern part* .	„	Turkey in Asia, Persia, Tibet, China, Japan.
16.	*Tropical Asia*	„	Indian Empire, Asiatic Archipelago.
	AUSTRALIA, Etc.		
17.	*Oceanic Province*	„	New Guinea, and adjoining isles to the east.
18.	*Australia*	„	Australia and Polynesia.

* Pompper, "Die Säugethiere, Vögel, und Amphibien, nach ihrer geographischen Verbreitung tabellarisch zusammengestellt," 1841.

ZOOLOGICAL GEOGRAPHY:—MAP XII.

In the following Table, the Provinces are arranged into six Zones to render the effect of climate on the geographical distribution of the animals readily apparent.

TABLE SHOWING THE DISTRIBUTION OF BIRDS AND REPTILES OVER THE GLOBE.

Orders.	ZOOLOGICAL PROVINCES.																	
	Northern Frigid Zone.			North. Temperate Zone.			Northern Warm Zone.				Tropical Zone.				Southern Warm Zone.			S.Temp. Zone.
	Arctic America	Arctic Europe.	Arctic Asia.	North America	Central Europe.	Central Asia. *a.*	Central America	South Europe.	North Africa.	Central Asia. *b.*	Tropical America	Central Africa.	Tropical Asia.	Oceanic Prov.	South America	South Africa.	Australia.	Austral America
	NUMBER OF THE SPECIES.																	
BIRDS (*Aves*):																		
I. Birds of Prey (*Rapaces*)	10	19	4	20	26	14	11	31	26	12	53	11	31	4	9	28	3	3
II. Climbers (*Scansores*) . .	5	63	2	12	110	7	23	77	8	4	122	21	86	26	18	30	26	3
III. Songsters (*Oscines*) . .	14	8	9	72	9	20	72	6	67	16	319	113	192	69	52	107	51	5
IV. Gallinaceous Birds (*Gall.*)	4	12	5	10	11	8	15	13	17	20	45	22	72	15	5	12	24	2
V. Waders (*Grallatores*) . .	21	45	24	38	48	26	20	24	38	23	59	25	50	11	16	30	18	4
VI. Swimmers (*Natatores*) .	49	76	39	26	20	28	15	7	8	10	26	19	19	8	18	22	30	29
Total amount of the Species .	103	223	83	178	224	103	156	158	164	85	624	211	450	133	118	229	152	46
REPTILES (*Reptilia*):																		
I. Tortoises (*Testudines*). .	—	—	—	13	2	—	5	5	5	2	14	6	14	1	—	3	2	—
II. Lizards (*Sauria*) . . .	—	1	—	5	6	4	19	17	33	10	38	13	40	5	7	18	10	—
III. Serpents (*Ophidia*) . .	—	1	—	10	10	2	2	17	13	1	50	2	42	4	6	6	7	—
IV. Frogs (*Amphibia*) . . .	—	6	—	13	17	3	3	16	6	—	36	1	3	5	4	—	1	—
Total amount of the Species .	—	8	—	41	35	9	29	55	57	13	138	22	99	15	17	27	20	—

We see from this Table that the greatest number of species, both of Birds and Reptiles, occur in the Tropical Zone, gradually decreasing towards the Poles, with this distinction, however, that many species of the Birds extend to the Arctic provinces, while few Reptiles are there to be met with. One group of the Birds especially, viz., the swimmers, are two or three times more numerous in the Arctic than in the Tropical provinces. Still by far the greater number are within the latter. Tropical America contains 624 species of Birds and 138 of Reptiles, Tropical Asia 450 and 99, while the total amount of the others does not approach to one half.

Species and Individuals.—If we were to conclude from a large number of species that there must be a large number of individuals, we should come to erroneous conclusions, for such is frequently not the case. The Arctic and Tropical countries furnish a fine example,—at least in their Mammalian and Ornithological Faunas. There is a decided paucity of species in the Polar regions, and an immense variety in the Tropics; but, on the other hand, the multitude of individuals in the former is, in general, much greater than in the latter; we need only refer to the clouds of birds which hover upon the islands and shores of the North, or to the inconceivable myriads of penguins seen by Ross* on the Antarctic lands, where there was even not the smallest appearance of vegetation; and among the quadrupeds, to the thousands of fur-animals that are annually killed in the Arctic regions. Wrangel† gives a fine description of the animal life in the Kolyma district of Siberia, one of the coldest regions of the globe: the poverty of vegetation is strongly contrasted with the rich abundance of animals. Countless herds of rein-deer, elks, black bears, foxes, sables, and grey squirrels, fill the upland forests; stone foxes and wolves roam over the low grounds. Enormous flights of swans, geese, and ducks, arrive in spring, and seek deserts, where they may moult and build their nests in safety. Eagles, owls, and gulls, pursue their prey along the sea-coast; ptarmigans run in troops among the bushes, and little snipes are busy along the brooks and in the morasses. Baer narrates that a walrus-hunter, on the rocks of Nova Zemlia, caught in a few hours 30,000 lemmings; while in Australia, much superior in the number of species, and scarcely to be compared with that island in superficial extent, a traveller will frequently journey for weeks together, and pass over many hundred miles of country, without meeting with a single quadruped.

* Ross, "Voyage to the Southern Seas," vol. i., p. 189.

† Wrangel, "Narrative of an Expedition to the Polar Sea in 1820—23," English edition, 1840, p. 51.

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ETHNOGRAPHY.

XIII. MAP OF THE WORLD, SHOWING THE DISTRIBUTION OF THE HUMAN RACE;

WITH

SYNOPTICAL TABLES OF THE HUMAN RACE.

This Map shows the present distribution of Man. The six great groups which we have adopted are distinguished by tints of shading, with the exception of one, that of the Iranian nations, which is left blank. The subdivisions of these groups are indicated by dotted boundaries, mostly coloured; and still more minute divisions are inscribed with their names, or letters referring to the Synoptical Table at the bottom of the Map. Thus we have, for example, the first group—that of the Iranian nations—distinguished by three different colours: pink for the Indo-European nations, blue for the Semitic, and yellow for the Egyptian and other nations. The Indo-Europeans, again, are divided into fifteen nations,—the names of which are inscribed on the Map, except in some cases where space was insufficient,—as, for instance, the Kurds and Armenians, which are indicated by letters of reference.

The Indo-European nations (marked by red colour) occupy comparatively the largest space of the globe. For three centuries and a half the Europeans have been emigrating in all directions, and settling in all parts of the world,—the Germanic and Greco-Latin nations chiefly in a westerly, and the Slavonians in an easterly direction,—(*see* the red strips and spots in Northern Asia, showing the extent of the Russian colonies). In most of the countries in which the European plants his foot, the aboriginal population is driven away, and generally extirpated. We see this in North America, Africa, and Australia: Northern Asia forms an exception, and likewise South America. In the latter continent the descendants of the original inhabitants still inhabit the same countries which were possessed by their progenitors three hundred years ago when the Spaniards immigrated. For, even then, as now, the Muïscas, Inca-Peruvians, and Aïmaras, inhabitants of the Andian table-lands, were stationary agricultural nations. With the exception of the Muïscas, which have mostly disappeared, these mountaineers have not only not decreased in number, but probably increased from the epoch of the discovery of America. The language, also, of the Inca-Peruvians, and of the Aïmaras, has remained the general medium of communication among themselves; and the latter has even become predominant with the Spaniards and their descendants. A similar case occurs in Brazil, where one of the Tupi dialects has become the general language, "lengua geral," even of the Portuguese. Thus, the agricultural Indians of the table-lands of South America, as well as of Mexico, not only increase in number and power, but improve in intelligence and education; so that, in the latter respect, many now take rank with the Spaniards, their former masters. The districts where Europeans are not decidedly predominant over the native Americans is indicated on the Map by a shading of streaks. (*See* Mexico and South America.)

Berghaus* has given a map showing the territorial extent of the different religions in the world. The portion designating the Christian religion corresponds with the red districts of Map, except India, the seat of the Brahminists. The district of the Buddhists comprises the Indo-Chinese nations and Mongols Proper (*see* the yellow and violet districts of Map), and that of the Mahometans, principally the Semitic and Turkish (*see* blue and green districts). The Heathens comprise the remaining nations; viz. those of Northern Asia, Central Africa, the greater part of Australia and America; while the Jews are distributed in different parts of the globe. The aggregate number of individuals belonging to the several religions, is thus estimated by Berghaus:

Christians	390,000,000
Jews	4,000,000
Mahometans	200,000,000
Brahminists	170,000,000
Buddhists	397,000,000
Heathens	111,000,000
Total inhabitants of the globe	1,272,000,000

With respect to occupation, the human race may be divided into three groups:—Agricultural, Nomadic, Fishing and Hunting nations. The two last bear a proportion of only one per cent. to the total population, though they occupy a considerable area; viz., Australia, Northern Asia, and all America,—except within the districts of the Indo-Europeans. The Nomadic tribes chiefly occupy the deserts of the Old World; viz., the Sahara,

* "Physikalischer Atlas, Abtheilung Anthropographie," No. 4.

ETHNOGRAPHY:—MAP XIII.

Arabia, part of Southern Africa, the Great Gobi, the Steppes of the Kirghis (*see* Maps I. and II.), and part of Northern Asia; in America only a small portion of the Pampas. The Agricultural nations occupy the largest area of the globe. The proportionate numbers of each division are estimated thus:

Agricultural nations	83	per cent., or	1,056,000,000
Nomadic „	16	„	203,000,000
Fishing and hunting	1	„	13,000,000
	100		1,272,000,000

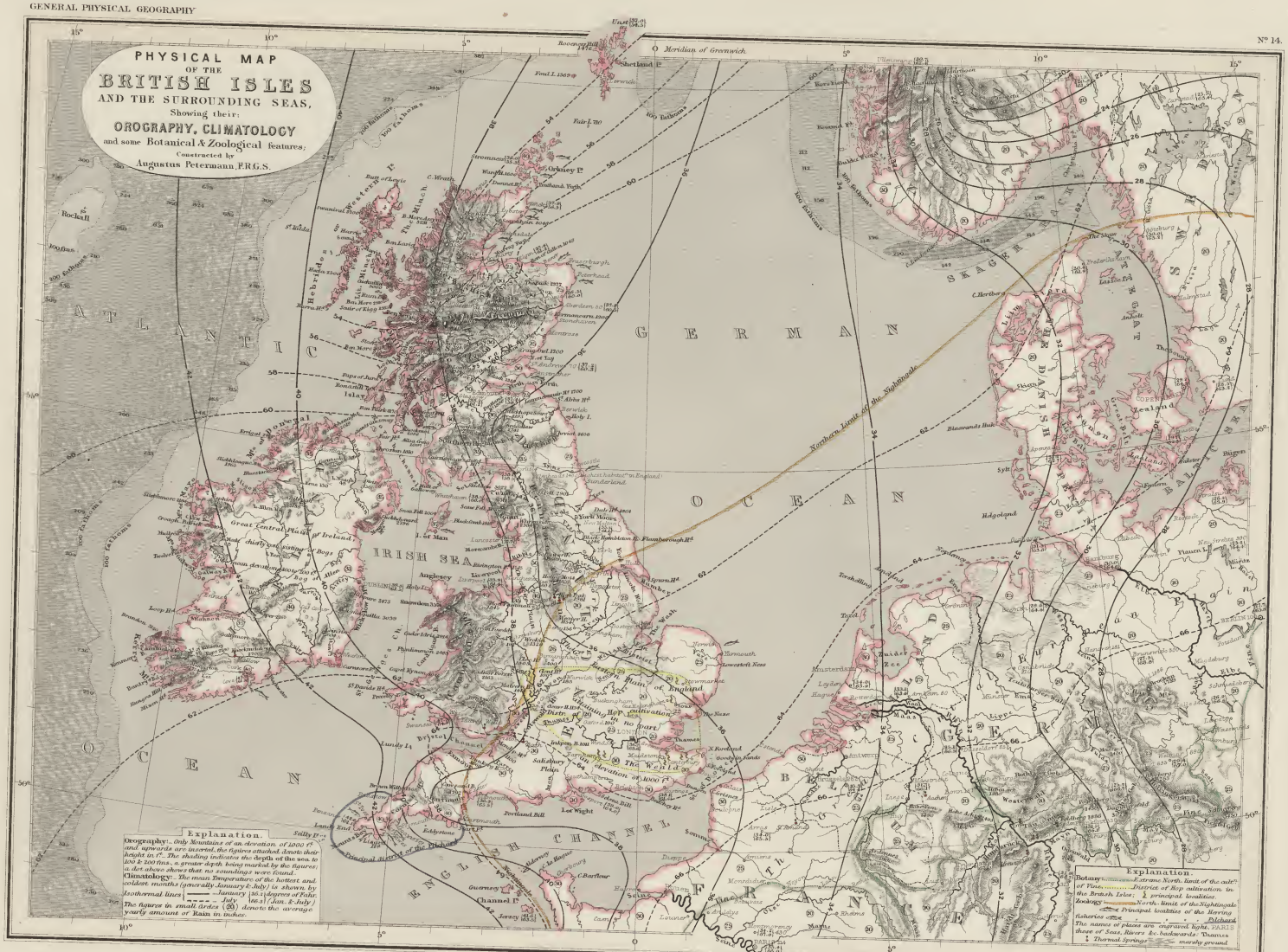
The distribution of the human race, according to the comparative area allotted to different nations, is very unequal. If we take the great quarters of the globe, the difference is very material, as will be seen from the following rough estimates: *

	Total area, sq. miles.	Total population.	Number of souls to one sq. mile.	Number of acres to one individual
Europe	3,673,880	296,000,000	81	8
Asia	14,190,000	652,000,000	46	14
Africa	11,580,000	275,000,000	24	27
America	18,760,000	47,000,,000	$2\frac{1}{2}$	255
Australia and Polynesia	3.400.000	2,000,000	$0\frac{3}{5}$	1088
Whole Globe	51,603,880	1,272,000,000	25	26

In England there are $2\frac{1}{5}$ acres to one individual, in Ireland $2\frac{1}{2}$, in Wales $5\frac{1}{3}$, and in Scotland $7\frac{1}{8}$. In East Flanders only 1 acre, and in the manufacturing districts of Lancashire and the West Riding of York, scarcely $\frac{1}{4}$ acre. †

* *See* Berghaus, "Grundriss der Geographie," 1843.

† Petermann, "Population Map of the British Isles," 1849.



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XIV. PHYSICAL MAP OF THE BRITISH ISLES AND THE SURROUNDING SEAS,

SHOWING THEIR OROGRAPHY, CLIMATOLOGY, AND SOME BOTANICAL AND ZOOLOGICAL FEATURES.

On this sheet we give a representation of our own islands on a larger scale, delineating several of its more important physical phenomena, and these somewhat more in detail.

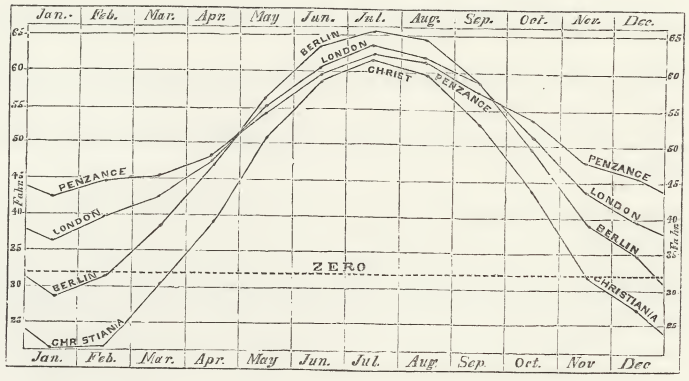
First of all, there are the grand features of the *configuration of the surface*, together with an indication of the depth of the sea; and here it must be observed, that a rigorous discrimination has been made to distinguish between high and low, deep and flat; for it is a very general error in maps that mountains are indicated without any regard to their comparative altitude. All eminences under an elevation of 1000 feet are omitted in the Map, as this line may be considered a limit between mountains and hills. Consequently no hills are marked in the south-east portion of England, with the exception only of the Inkpen Beacon. On the other hand, all elevations of more than a thousand feet, of whatever extent, are inserted; the Cleave Hills, near Cheltenham, the Clint Hills, near Birmingham, and the numerous small isolated groups in Ireland, forming the lowest in rank. A similar distinction has been made in representing the depth of the sea; all diversities not amounting to 100 fathoms deep are disregarded; the depths of 100 and 200 fathoms are marked with lines, and the intermediate spaces with different tints of shading, Consequently, the lightest tint of this Map comprises all the sea to a depth of 100 fathoms, which extends over a great space, nearly comprising the entire German Ocean, and to the west beyond St. Kilda, in general 25 to 70 miles from the land; and here the bottom of the sea very suddenly sinks to a great, and at present unknown, depth, for between St. Kilda and Rockall no bottom was found at 960 fathoms. The following section shows the greatest elevation and depth of British land and sea, extending from west to east through the following points:—Rockall, sounding of $\frac{1}{960}$, Hecla in S. Uist, Rum Island, Ben Nevis, Central Grampians, Stonehaven to Cape Lindesnaes in Norway. The horizontal scale is in correspondence with the Map, while the perpendicular one is thirty times larger.

The British Isles stand on an extensive platform or true table-land, as we distinctly see from this section. Such is the general depth of the German Ocean, that it appears a great flat in comparison to the depth between Hecla and Rockall, and also to that at the Scandinavian coast; this long narrow hole sinks down to 443 fathoms in the Skager Rack. On this oceanic table-land the British Isles stand out very prominently. Rockall forms the culminating point of an oceanic mountain-range, which seems to extend considerably in a south-west direction nearly parallel with the edge of the table-land (the 100 fathom line); but the measurements have only extended to lat. $55\frac{3}{4}°$ N.

The next subject of Physical Geography represented in the Map, is that of Meteorology; viz., the distribution of *Temperature and Rain*. Two kinds of bold curves (broken and continuous) show the extreme difference of the distribution of temperature within the annual period; viz., Isothermals of January and July, the coldest and hottest months of the year. The average direction of the January isothermals is from north to south, that of the July isothermals from south-west to north-east, implying the greatest cold in winter in the east instead of the north. Thus the Map exhibits the fact that the continental countries corresponding in latitude with the British Isles are colder in winter and hotter in summer than the latter, constituting what is termed a continental and insular climate. A further illustration of this subject is given in the following Diagram, showing in curves he mean monthly temperature of places belonging to insular and continental climates. Among the four places selected, the most insular

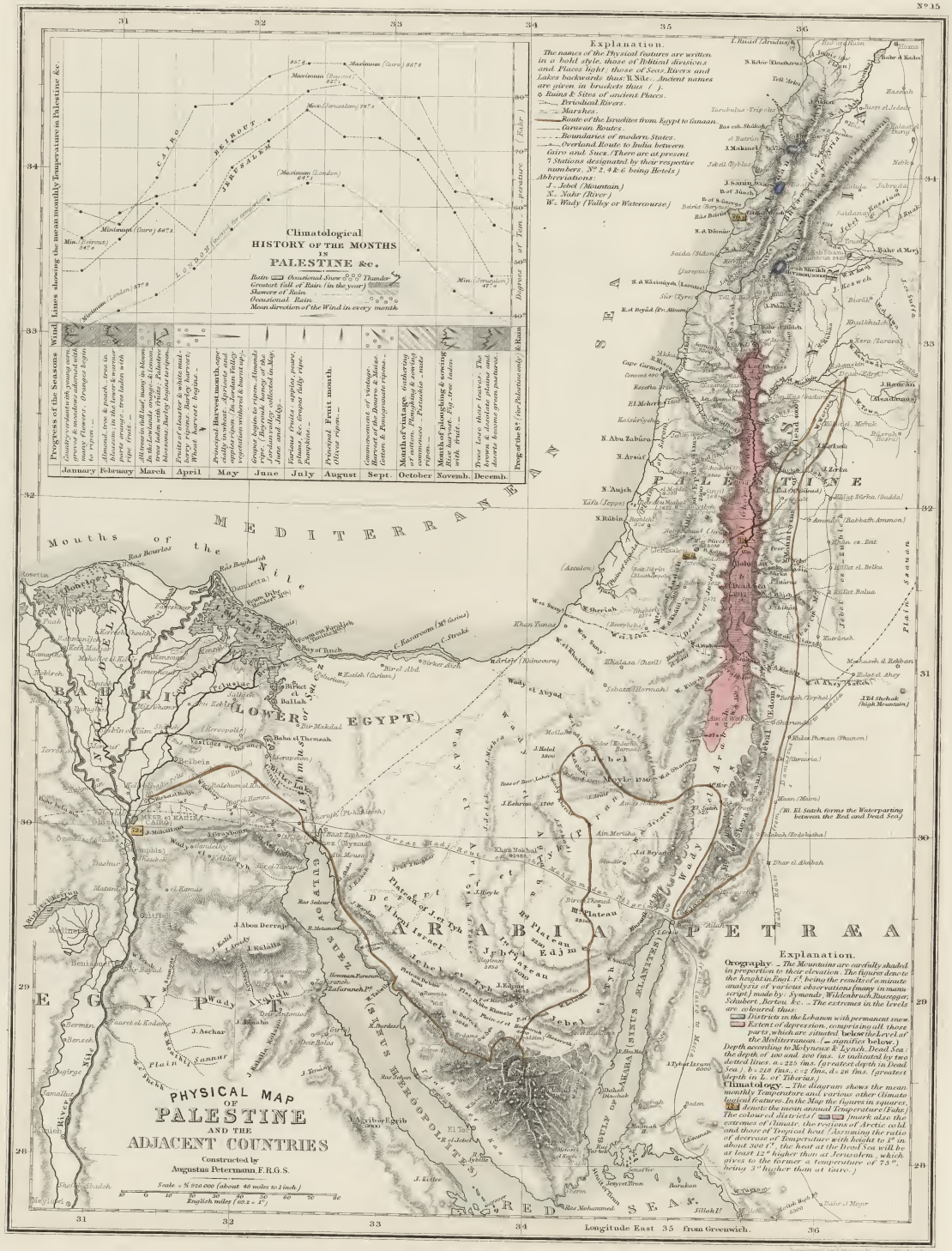
PHYSICAL MAP OF THE BRITISH ISLES:—MAP XIV.

climate is represented by Penzance (difference between hottest and coldest month 19°·5), the most continental by Christiania (difference, 40°·5). It is remarkable to see how the temperature in these four places so nearly coincides in the height of summer (difference between Christiania and Berlin, only 4°.6), while such considerable diversity exists in the height of winter, as amounts to nearly 22°.



The figures of rain (*see* small circles) indicate the average yearly amount for those districts in which the figures are placed. These data are derived—for the British Isles, from the Author's researches;* for the Continent, from "Berghaus's Physical Atlas."

* Petermann, "Hydrographical Map of the British Isles," 1849.



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XV. PHYSICAL MAP OF PALESTINE, AND THE ADJACENT COUNTRIES;

WITH

DIAGRAM, SHOWING THE CLIMATOLOGICAL HISTORY OF THE MONTHS.

PALESTINE, in point of physical geography, is one of the most singular countries of the world; but till very lately our knowledge of it was extremely defective, despite of the hosts of travellers that have been visiting it for many centuries back. It was from the absence of scientific measurements, particularly of the comparative elevation of the country, that many questions in the Biblical and physical history of the Holy Land remained unsolved. The discovery, about ten years ago, of the depression of the Dead Sea below the level of the ocean, forms undoubtedly the most important epoch in our history of this country; for only now, by the results of this discovery, is the very striking difference between the temperature, climate, and productions of this depressed region, as compared with other regions, easily and satisfactorily explained.

The beautiful observation of the Arabian poets: "The Lebanon bears winter on his head, spring on his shoulders, and autumn in his bosom, while summer lies sleeping at his feet,"—is applicable to the climate of Palestine generally, for such is the diversity of levels in its configuration, that four regions are marked out by nature, strikingly distinguished by difference of climate and vegetation. These regions are long strips of land, parallel with the coast, which runs in a general direction from north to south:

1. *The region of depression*, being that of the Ghor and northern portion of the Wady el Arabah. Elevation, 1 to 1300 feet *below* the level of the ocean. Mean annual temperature, 75° to 70°. (This region is marked on the map by red colour.)

2 *The littoral plains*, comprising the low countries along the Mediterranean. Elevation, from 1 to 500 feet. Mean annual temperature, 70° to 68°. (This region comprises the plains of Sephela, Saron, and Akka of the map.)

3. *The table-lands*, comprising the elevated countries on both sides of the Jordan valley. Elevation, from 2000 to 3000 feet. Mean annual temperature, 63° to 60°.

4. *The Lebanon*, comprising its higher portions. Elevation, from 4000 to 10,000 feet. Mean annual temperature, as low as 35°, roughly estimated. (The summits covered with permanent snow marked blue on the map.)

These regions may also be denominated,—the tropical, warm, temperate, and cold region:

1. *The region of depression* may be described as a long and broad gulley, or a continuous ravine, limited at both sides by considerable declivities, and traversed in the middle by the Jordan. The vegetation is abundant and luxuriant in most parts; but in the height of summer usually burnt up, owing to the excessive heat. Travellers generally think they have passed into another zone, when descending from Jerusalem to Jericho. Josephus even mentions, that the winter in the plain of Jericho resembled spring, and that the inhabitants were clothed in linen garments at the time that people of other parts of Judea were shivering in the midst of snow. Snow, indeed, is almost entirely unknown in the Ghor; dates become ripe early in July, while they are later even in Egypt. Such a phenomenon could not be explained before the remarkable depression of the Dead Sea was ascertained, which amounts to 1312 feet;* added to this, the height of Jerusalem above the sea being at least 2200 feet, the difference in round numbers will be 3500 feet, and such a height implies a difference of temperature of about 12°. This gives for the Ghor, in its lower portions, 75°, which would seem to corroborate the fact of dates ripening earlier there than in Egypt, as the temperature of Cairo is only 72°.

2. *The regions of the littoral plains* are comparatively much milder in climate, and Shaw's observation that corn is as forward on the plain of Jericho as it is in the plain of Acre a fortnight after, is confirmed by Wildenbruch, who found the harvest of wheat near Jericho fully begun, while in Beirût and Yâfa it commenced a month later. Actual observations give for Beirût a mean annual temperature of 69°·3. The winter is so moderate that the orange, banana, and other delicate trees, flourish in the open air; and it appears equally extraordinary and picturesque to an European at Tripoli to behold under his windows, in the month of January, orange-trees laden with flowers and fruit, while the lofty head of Lebanon is seen covered with ice and snow.

3. *The table-lands* exhibit a temperature of 6° to 8° lower than the plains, and approach the climate of southern Europe; the mean annual temperature of Jerusalem corresponds very nearly with that of Palermo, Barcelona, and Oporto, places situated from 6° to 10° of latitude further to the north. Round Jerusalem everything ripens several weeks later than at Jericho. Sometimes as early as in May the whole valley of the Jordan appears as if in the midst of summer, every plant being already dried up, when, at the same time, the plains of the Haouran are covered with the richest verdure of wild herbage. The table-lands of Palestine, as viewed from the Ghor, are from 3000 to 4000 feet higher, and surpass greatly in height the table-lands of Bavaria, Spain, and others of Europe.

4. *The Lebanon*, the fourth region, indicates the opposite to the deeply depressed Ghor. Some observations† on the snow in these mountains may be added. *(See district coloured blue in Map.)* On the plateau of *Jebel Sanin*, (9350 feet) perpetual snow lies in the crevices and crater-like hollows, in immense quantities, forming a compact mass, which is cut up with hatchets by the people, who convey it to Beirût. This business is carried on for about six months, from May to November. Besides Jebel Sanin, permanent snow lies only on the highest crest of the Lebanon, viz., the *Jebel Makmel* (9375 feet) at the origin of Wady Kadisheh, above Kanobin and the cedars, north of the road which leads from Bsherreh to Ainata, Khan-el-Akhmar, and Baalbeck. Everywhere on the western side, the snow remains only in the crevices, disappearing at the end of May from the surface of the mountains; on the eastern side, however, it occupies the surface throughout the summer months when the fall has been considerable; but even then in comparatively small patches, not amounting to 1000 square feet. In the Anti-Lebanon, on the tops of the *Jebel esh Sheikh* (10,000 feet?), there is more snow than on the Lebanon, yet no continuous snowfields occur. In the Bûkâa (Cœle-Syria) snow lies often several days in winter.

* On the depression of the Jordan valley, see Petermann "On the Fall of the Jordan," &c., in "Journal Royal Geogr. Soc.," 1848.

† Communicated by Colonel von Wildenbruch, in MS.

PHYSICAL MAP OF PALESTINE:—MAP XV.

The diagram (*see* Map) illustrates the diversity of climate of various places, particularly as to the course of temperature in every month; and for comparison with our own climate, the curve of London has been inserted. Thus we see, for example, that the highest monthly temperature of London corresponds with that of Jerusalem in the beginning of May and end of October, and with that of Beirût in the end of April and beginning of November. The lowest temperature of Cairo corresponds with that of May in London.

It is sufficiently evident, from the few preceding remarks, that in studying the geography or history of the Holy Land, its Orography must be carefully considered,—a clear and distinct conception of the great features of the configuration of its surface must first be obtained; and in order to make these as prominent as possible in the Map, political boundaries and other similar features have been introduced in light characters. Figures of altitude are inserted to the principal mountains, table-lands, places, lakes, passes, &c., containing many important data hitherto unpublished, among which the following are derived from the trigonometrical surveys of Captain Symonds.

West of the Lake of Tiberias.

Jebel Coucab		1754·4 feet.
Little Hermon		1862·4 „
El Meherka	summits of Mount Carmel	1598·2 „
Essefia	summits of Mount Carmel	1725·9 „
Mount Carmel Convent		489·4 „

West of the Dead Sea.

Mount of Olives	2397·8 feet.
Nebi Samuel, village	2648·6 „
Taiyibeh, (Ophra,) village	2565·1 „
Deir Abu Meshal, convent	1477.0 „
El Mejdel, village	393·0 „
Martyr's Tower, near Ramleh	326·1 „

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